ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND ALEX. RICHARDSON.

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OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CXII.—No. 2896.] *LONDON: FRIDAY, JULY 1, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Advertisement last week, page 109.

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Specification and Workmanship equal to Main Line Locomotives.
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Sizes 2½ B.HP. and upwards.
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SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
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NAVAL OUTFITS A SPECIALTY.

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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2467
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ALSO FOR
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(UP TO 35 TONS.)
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See Illustrated Advertisement Page 100, Jan. 28.

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See Advertisement page 101. 9091

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Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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Coal Strike is Settled 9048
is the favourable opportunity of having your chimney shaft inspected and renovated by highly skilled expert chimney shaft builders and repairers.
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROW'S PATENTS
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS,
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Matthew Paul & Co., Ltd.
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See Full Page Advt., page 77, June 24.

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HALESOWEN. 7116

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 9350
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LARGE STOCK of NEW PRESSES now on view in our Showrooms, Constitution Hill.
TAYLOR & CHALLEN, LD., Engineers, Birmingham.
See Full Page Advertisement page 72, June 24.

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Parliament Mansions, Victoria St., London, S.W.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9060
See half-page Advertisement, page 74, June 10.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. H. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
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The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

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All communications to— Head Office—
H. W. RHID, 98, Belgrave Road,
General Secretary. Victoria, London, S.W.1.

ROYAL AIRCRAFT ESTABLISHMENT.

An Examination for the entry of TWELVE TRADE LADS in the above Establishment will be held on Tuesday, July 26th, 1921. Application for admission to the examination must be made on the form provided, which form, properly filled in, must be returned not later than Wednesday, July 13th.
Application forms and the regulations governing the conditions of entry and training of Trade Lads may be obtained by post from:
THE SUPERINTENDENT,
Royal Aircraft Establishment,
South Farnborough,
Hants.
Or by personal application at the
Employment Department,
Royal Aircraft Establishment,
South Farnborough.
R 302

THE
University of Liverpool.
SESSION 1921-22.

AUTUMN TERM BEGINS OCTOBER 6TH, 1921.

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ELECTRICAL ENGINEERING.
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Lecturer—R. O. STREET, M.A., M.Sc.
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Lyon Jones Professor—L. R. WILBERFORCE, M.A.
Senior Lecturer—J. RICE, M.A.
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Grant Professor of Inorganic Chemistry—R. C. C. BALY, C.B.E., M.Sc., F.R.S.
Senior Lecturer in Analytical Chemistry—J. SMEATH THOMAS, D.Sc.
GEOLOGY.
George Herdman Professor—P. G. H. BOSWELL, O.B.E., D.Sc., M.Inst.M.M., F.G.S.
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EDWARD CARBY, Registrar.
L 585

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TENDERS.

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Board of Directors of H.E.H. The Nizam's Guaranteed State Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

(I) 11 STEEL UNDERFRAMES, for Bogie Carriages (Metre Gauge).
(II) 44 PAIRS OF WHEELS AND AXLES for the above.

For each copy of the Specification (i) or (ii) a fee of Ten Shillings will be charged, which is not returnable. Tenders enclosed in sealed envelopes and addressed to the Chairman and Directors, and endorsed "Tender for Underframes," or "Tender for Wheels and Axles," as the case may be, must be delivered at the Company's Offices, not later than Twelve noon on 18th July, 1921.
The Directors do not bind themselves to accept the lowest or any Tender, and reserve the right to divide the order.

By Order of the Board,
F. ADAMS,
Secretary.

Winchester House,
50, Old Broad Street,
E.C. 2.
22nd June, 1921. R 276

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and

DELIVERY of:—
(1) 200,000 CAST IRON D.O. SLEEPER PLATES.
200,000 CAST IRON LOOSE JAWS FOR SAME.
(2) 100,000 MILD STEEL TIE BARS.
200,000 MILD STEEL COTTERS.
200,000 MILD STEEL GIBS,
as per specifications to be seen at the Company's Offices.
Tenders are to be sent to the undersigned, marked "Tender for Cast Iron Sleeper Plates," or as the case may be, not later than Eleven o'clock a.m., on Wednesday, the 13th day of July instant.
The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any tender.
For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. B. LILLIE,
Secretary.

Nicholas Lane, London, E.C 4.
1st July, 1921. R 300

CITY OF SHEFFIELD.

ELECTRIC SUPPLY DEPARTMENT.

CONTRACT No. 297.
REINFORCED CONCRETE OR STEEL BRIDGE TO CROSS THE GREAT CENTRAL RAILWAY CO.'S MAIN LINE.

The Electric Supply Committee of the City of Sheffield are prepared to receive

Tenders for the Above.

Contractors desiring to submit Tenders may obtain the Drawings, Specification, Form of Tender and Conditions of Contract at these Offices on or after Monday, 27th June, 1921, on payment of a sum of £3 3s. which will be refunded on receipt of a *bona fide* Tender, with which must be enclosed the Drawing, Specification and General Conditions of Contract, each one to be signed by the Contractor, and the Drawing to have endorsed thereon the type of Bridge tendered for; or on the return of the whole of the documents within four days of their receipt by the Contractor in the event of his inability to submit a Tender.
Any person or firm sending in a Tender will be required to add a Schedule to such Tender stating the names of the various classes of labour which he or they intend to employ, together with the place where such labour will be employed, and the rates and wages, hours of labour and conditions of employment to be paid and observed in respect of each class of labour, all of which, as shown in such Schedule shall comply with the City Council's form of clauses respecting wages, hours and conditions of labour and prohibition against assigning or sub-letting.
Tenders, which must be made out on the official Tender Form, to be delivered at these Offices (enclosed in the official envelope provided), not later than Ten o'clock on Tuesday morning, 19th July, 1921.

S. H. FEDDEN,
M.Inst.E.E., M.I.M.E., M.Inst.C.E.
Commercial Street,
Sheffield. R 288

CITY OF NOTTINGHAM.

TO STRUCTURAL ENGINEERS.

The Electricity Committee are prepared to receive

Tenders for about 150 Tons

of IRON and STEELWORK, in Stanchions, Roof Trusses, ordinary and plated joists, framing, corrugated sheeting, etc., in connection with the CONSTRUCTION of the NEW GENERATING STATION, near Clifton Colliery, in the City of Nottingham.
Drawings may be seen, and copies of the General Conditions of Contract, Specification, Bill of Quantities, and Form of Tender, etc., may be obtained, on and after Monday, 4th July, 1921, on application to Mr. ARTHUR BROWN, M.Inst.C.E., City Engineer, Guildhall, Nottingham, on payment of a deposit of £2, which will be returned on receipt of a *bona fide* Tender, and the copy of the Specification.
Sealed Tenders, duly stating the time required for the completion of the work, and the source from which the material is proposed to be obtained, are to be delivered, in the Official Envelope provided, to the undersigned on or before THURSDAY, 14th JULY, 1921.
The lowest or any tender will not necessarily be accepted, and Tenders will only be accepted from persons who conform to the conditions of the Contract as regards paying the local standard rate of wages, etc., and to the working rules of the Nottingham district.

By Order,
W. J. BOARD,
Guildhall, Town Clerk.
Nottingham.
30th June, 1921. R 315

LONDON COUNTY COUNCIL.

Tenders are Invited for (1)

REPAIRS to the GRANITE SETT PAVEMENT of the Carriageways of Blackwall and Rotherhithe Tunnels. (2) REPAIRS to GRANITE CHANNELLING, Rotherhithe Tunnel.
Specifications, Bills of Quantities, Form of Tender, Drawings, etc., may be obtained from the CHIEF ENGINEER at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £3 in each case. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and the other contract documents may be inspected at the County Hall before the payment of the fee. No Tender received at the County Hall after Four p.m. on Monday, 11th July, 1921, will be considered.

JAMES BIRD,
Clerk of the London County Council. R 304

MANCHESTER CORPORATION WATERWORKS.

THIRLMERE AQUEDUCT—4TH PIPE LINE.

WELDED STEEL PIPES.

The Waterworks Committee invite

Tenders for the Supply of

about 3700 tons of 54 in. WELDED STEEL PIPES and SPECIALS. Specification, and Form of Tender, etc., may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, on payment of the sum of THREE GUINEAS which will be returned to the TENDERER provided that he shall have sent in a *bona fide* Tender on the form provided. Sealed Tenders, endorsed "Tender for Welded Steel Pipes," and addressed to the Chairman of the Waterworks Committee, must be delivered at the Waterworks Offices, Town Hall, Manchester, not later than Monday, the 11th July, 1921.

By Order,
THOMAS HUDSON,
Town Clerk.

Town Hall, Manchester,
28th June, 1921. R 335

APPOINTMENTS OPEN.

UNIVERSITY OF GLASGOW.

CHAIR OF NAVAL ARCHITECTURE, including MARINE ENGINEERING.

The University Court will,

about the beginning of next session, PROCEED to FILL the VACANCY in the Chair of Naval Architecture, including Marine Engineering, caused by the retirement of Professor Sir JOHN H. BILES.
Information regarding the Chair may be obtained on application to the SECRETARY of the University Court, The University, Glasgow.
June, 1921. R 378

ROYAL NAVAL COLLEGE, GREENWICH.

Applications are Invited

for the following APPOINTMENTS to the Professorial Staff of the ROYAL NAVAL COLLEGE, GREENWICH, to date September 1st, 1921:—
MATHEMATICS.—FOUR INSTRUCTORS. Two of these appointments are permanent and two, in the first place, for one year. Good Honours Degree in Mathematics essential.
PHYSICS.—THREE INSTRUCTORS, to teach General Physics and Applied Electricity. One appointment is permanent and the others, in the first place, for one year. Qualifications: good Honours Degree in Physics, Natural Science or Electrical Engineering; teaching experience, together with experience of either Research or Electrical Works Practice, desirable.
APPLIED MECHANICS.—TWO INSTRUCTORS, to be appointed in the first place, for one year, to undertake lecture and laboratory work in Engineering subjects for classes of University standard. Candidates should have experience in Engineering practice, and in teaching.
The scale of remuneration for permanent appointments in each case is £500 rising by £25 annually to £600; plus 10 per cent. of salary paid by the Government towards pensions fund.
Instructors appointed on a temporary basis will receive an inclusive salary not exceeding £600 per annum. Should they be retained after one year they will be placed on the above permanent scale at £525.
Applications, together with statement of qualifications and experience, and copies of recent testimonials to be forwarded before July 11th to
THE SECRETARY OF THE ADMIRALTY,
Whitehall, S.W. 1. R 164

Estimator (Cost) Required by

firm Engineers and Boilermakers in London. Only men with drawing office and previous estimating experience need apply. State full particulars and salary required.—Address, R 314, Offices of ENGINEERING.

Required at Once the

services of a good MAN to supervise running, repairs and maintenance of two to three thousand railway wagons. Practical knowledge of wagon construction and maintenance absolutely essential. —Apply, stating full details of experience, age and wages required, to HEADSTOCK, F. 971, 84, Union Street, Birmingham. R 310

Opening has Arisen for a

London ENGINEERING SALESMAN with a first-class connection, to represent on commission a leading firm of Welders.—Address, R 303, Offices of ENGINEERING.

Engineer. — Wanted Mech-

ANICAL and ELECTRICAL ENGINEER for Chemical Works in Liverpool district, essential must have had good practical experience in organisation and in controlling costs and production, knowledge of chemistry desirable but not a sine qua non.—Write, stating age, detailed experience and salary required, to BOX S 976, LEE and NIGHTINGALE Advt. Offices, Liverpool. R 289

CITY OF BRADFORD.

TECHNICAL COLLEGE.

Applications are Invited for

Appointment as HEAD of the DEPARTMENT of CIVIL ENGINEERING in the College.
A salary up to £700 per annum will be paid to a candidate of suitable qualifications and experience.
The conditions of appointment and forms of application may be obtained from the Principal, Technical College, Bradford. Forms of application endorsed "Technical College, Civil Engineering Appointment," should be returned so as to reach the undersigned not later than 9th July, 1921.

N. L. FLEMING,
Town Clerk.
Town Hall, Bradford, 30th June, 1921. R 343

PORTSMOUTH MUNICIPAL COLLEGE.

Principal, OLIVER FREEMAN, Wh.Sc., A.R.C.S., B.Sc.

APPOINTMENT OF HEAD OF ENGINEERING DEPARTMENT.

The Higher Education Committee invite

Applications for the Appoint-

MENT of HEAD of the ENGINEERING DEPARTMENT.
Candidates must have qualifications in Mechanical Engineering and should hold a Degree of a British University.
Salary: £487 10s. to £525 per annum (by two annual increments) with addition for 1st Class Honours Degree.
Further particulars and Form of Application may be obtained from the undersigned, to whom applications should be returned as early as possible, accompanied by copies only of not more three recent testimonials.

H. E. CURTIS,
Secretary.

Offices for Higher Education,
The Municipal College, Portsmouth,
A. 28th June, 1921. R 307

1. THE SUDAN GOVERNMENT RAILWAYS AND STEAMERS DEPARTMENT desire the

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He should be a thoroughly trained Engineer, have expert knowledge of steamer construction, especially shallow draft craft. Thorough practical and theoretical knowledge and should have passed the examination of A.M.I.C.E., and have held some post of responsibility.
Age 30-35. Preferably unmarried.
Salary £E 780 per annum rising to £E 1080 by laid down scale, plus £E 120 per annum temporary war bonus.
Pensionable service after satisfactory probation.
2. The Sudan Government Railways and Steamers Department Desire the SERVICES of a LOCOMOTIVE ENGINEER for the Post of Running Superintendent. He should have served a pupilage on a British Railway or in a large locomotive works, and passed the examination of A.M.I.C.E. He should have ability to deal with all classes of Mechanical Engineering connected with a railway. Able to control a large staff and have previously held a position of responsibility on a Railway.
Age 30-35; preferably unmarried.
Salary £E 780 per annum, rising to £E 1080 by laid down scale, plus £E 120 per annum temporary war bonus.
Pensionable service after satisfactory probation.
Applications together with copies of testimonials, should be forwarded to the INSPECTING ENGINEER, EGYPTIAN AND SUDAN GOVTS. Queen Anne's Chambers, Broadway, Westminster, S.W. 1. R 291

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with experience in structural work and the arrangement of plant and machinery; one of them should also have electrical experience.
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ENGINEERING.

THE CALCULATION OF CRITICAL SPEEDS.

In a notable paper, which constituted, in fact, a veritable mine of valuable information, contributed to the Proceedings of the Institution of Electrical Engineers in 1912, Mr. K. Baumann gave a rule for the critical speed of turbine rotors, which, from the context, appears to have been arrived at empirically. He said that if the maximum deflection δ of the rotor under gravity were calculated, then it had been found by actual trial for a large variety of rotors that the critical speed was given by the relation

$$\delta\,\omega^2 = (1{\cdot}07 \text{ to } 1{\cdot}08)\,g.$$

In this expression ω denotes the angular velocity in radians and g the acceleration due to gravity.

Naturally an empirical rule of this kind cannot be expected to apply to all types of rotor, but it is possible to obtain nearly as simple an expression applicable in all cases, by making use of the late Lord Rayleigh's method of estimating the natural periodicity of vibration of a loaded shaft; which is, as is well known, identical with the critical speed.

The formula is given in most textbooks on the steam turbine and may be put in the form

$$\omega^2 = \frac{386{\cdot}4\int_0^l p\,\delta\,dx}{\int_0^l p\,\delta^2\,dx}$$

In this expression p denotes the load per inch run at any point of the rotor, and δ the deflection (under gravity) of the rotor at the same point; whilst l is the total length of the rotor between centres of bearings and 386·4 is the value of gravity in inches per sec.^{2} In practice it is a very tedious operation to evaluate these integrals if treated in the usual way, but a great simplification can be effected by making use of the relation

$$p = \frac{dS}{dx}$$

where S denotes the shearing force at any point of the rotor, which for this purpose, may be most conveniently dealt with as if supported at one end only, cantilever fashion.

If, in the integrals, we now substitute dS for $p\,dx$ we get

$$\omega^2 = \frac{386{\cdot}4\int_0^{S_l}\delta\,dS}{\int_0^{S_l}\delta^2\,dS} = \frac{386{\cdot}4\,.\,S_l\,(\text{mean value of }\delta)}{S_l\,(\text{mean value of }\delta^2)}$$

Cancelling out S_l from top and bottom, we get simply

$$\omega^2 = 386{\cdot}4\,\frac{(\text{mean value of }\delta)}{(\text{mean value of }\delta^2)}$$

In this expression δ represents the deflection of the rotor under gravity when supported in its bearings, and must be plotted against the shear, which is calculated on the assumption that the rotor is supported cantilever fashion.

Amongst the rules for determining mean values given by Roger Cotes over two centuries ago, we have the following: Let the base of a curve be divided into four equal parts and let y_0, y_1, y_2, y_3 and y_4 be the ordinates at the points of division.

Then the mean value of y is given by the relation

$$\bar{y} = \frac{7}{90}(y_0 + y_4) + \frac{16}{45}(y_1 + y_3) + \frac{2}{15}\,y_2.$$

Now, in the case of a turbine rotor, the deflection is zero at both ends, so that the mean value of the deflection is given by the relation

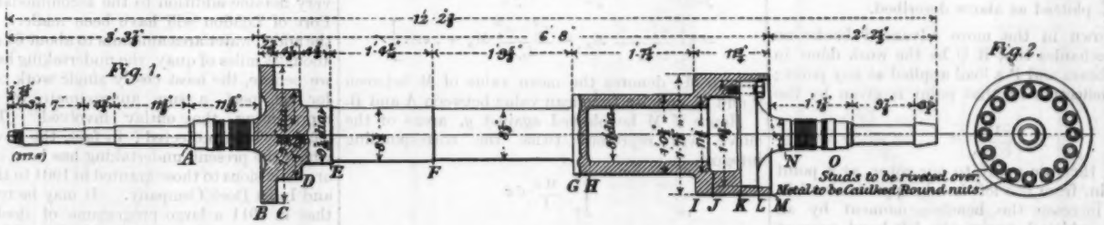
$$\bar{\delta} = \frac{16}{45}\left(\delta_1 + \frac{3}{8}\,\delta_2 + \delta_3\right)$$

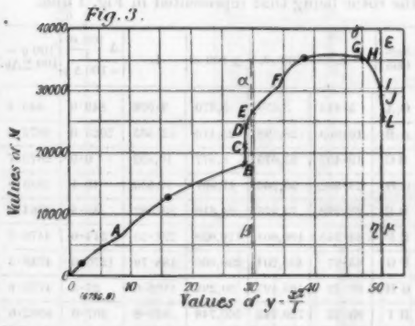
whilst—

$$(\bar{\delta^2}) = \frac{16}{45}\left(\delta_1^2 + \frac{3}{8}\,\delta_2^2 + \delta_3^2\right)$$

so that we get finally the following value for the critical speed:

$$\omega^2 = 386{\cdot}4\,\frac{\delta_1 + \frac{3}{8}\,\delta_2 + \delta_3}{\delta_1^2 + \frac{3}{8}\,\delta_2^2 + \delta_3^2}$$





This rule gives extremely accurate results, even in very complicated cases. Take, for example, the rotor represented in Figs. 1 and 2. The deflection curve of this has been very carefully calculated, with the results shown in the following table:—

Point.	Deflection Inches.	Point.	Deflection Inches.	Point.	Deflection Inches.
A	0·003399	F	0·010238	K	0·007204
B	0·007313	G	0·009919	L	0·007023
C	0·007647	H	0·009738	M	0·006832
D	0·008211	I	0·008099	N	0·006459
E	0·008833	J	0·007833	O	0·002692

Lord Rayleigh's rule, the integrals being calculated with great care, gave

$$\omega^2 = 45572$$

and Mr. Baumann's empirical rule gives

$$\omega^2 = 39970$$

which is not a bad result, considering the very awkward form of the rotor. Once the deflection curve has been obtained, however, it is very nearly as easy to apply the rule just given and there is a substantial increase in the accuracy.

When considered as a cantilever, the total shear S_l on the rotor at the centre of the supporting bearing

is 2338·2 lb., and we find, from the shear curve, that at a distance 27·94 in. from the centre of free bearing the shear is $\frac{S_l}{4}$; at 68·00 in. it is $\frac{S_l}{2}$ and at 88·11 in. it is $\frac{3\,S_l}{4}$. The corresponding deflections (as calculated with the rotor supported in both bearings and determined by interpolation from the figures tabulated above) are as follows:—

Shear.	$\frac{S_l}{4}$	$\frac{S_l}{2}$	$\frac{3\,S_l}{4}$
Distance	27·94"	68·00"	88·11
δ	$8{\cdot}502 \times 10^{-5}$	$9{\cdot}918 \times 10^{-5}$	$7{\cdot}812 \times 10^{-5}$
δ^2 =	$7{\cdot}228 \times 10^{-5}$	$9{\cdot}837 \times 10^{-5}$	$6{\cdot}103 \times 10^{-5}$

Hence

$$\delta_1 + \tfrac{3}{2}\,\delta_2 + \delta_3 = (8{\cdot}502 + 3{\cdot}719 + 7{\cdot}812) \times 10^{-5} = 20{\cdot}033 \times 10^{-5}$$

and

$$\delta_1^2 + \tfrac{3}{2}\,\delta_2^2 + \delta_3^2 = (7{\cdot}228 + 3{\cdot}689 + 6{\cdot}103) \times 10^{-5} = 17{\cdot}020 \times 10^{-5}$$

Hence finally

$$\omega^2 = 386{\cdot}4 \times 100 \times \frac{20{\cdot}033}{17{\cdot}020} = 45480$$

as compared with 45572 as found by accurate integration.

Unfortunately, the above rule, though it is very accurate, only simplifies the final step in the calculation.

The difficulty of calculating the deflection curve remains. This can be done arithmetically, but is a very tedious operation even when the work is systematised. Usually a graphical method is employed, the value of $\frac{M}{I}$; where M is the bending moment at any point and I the moment of inertia there, being plotted for every point of the span, and treated as an imaginary load curve. From this an imaginary bending moment curve is drawn by the ordinary methods of graphic statics. The imaginary bending moments thus found are proportional to the deflections at the corresponding points. This method is fully described in most books on the steam turbine. In many cases, however, the imaginary load curve turns out to be of a very bizarre character, not at all well-suited to graphic treatment.

In the method of determining critical speeds above described, we only require the deflection at three specified points, and in those drawing offices which are provided with an Amsler integrator, these deflections can be found immediately from the curve of $\frac{M}{I}$ plotted as above described.

It is shown in the more advanced books on Applied Mechanics that if U be the work done in bending a beam and P a load applied at any point; then the deflection at that point is given by the relation:

$$\frac{\partial U}{\partial P} = \delta$$

Suppose, then we apply to our rotor, at a point distant X in. from the left-hand support a load P. This will increase the bending moment by an amount m, which between the left-hand support and X, is given by the relation:

$$m = \frac{l - X}{l} P x .$$

so that for this portion of the rotor:

$$\left.\frac{dm}{dP}\right]_0^x = \frac{l - X}{l} x .$$

Similarly, if distances from the right-hand support are denoted by v, so that the point of application of the load is V in. distant from the right support, we get:

$$\left.\frac{dm}{dP}\right]_0^v = \frac{l - V}{l} v . = \frac{X}{l} . v .$$

Now if N denote the bending moment at any point of a beam, the work done in bending it is:

$$U = \int_0^l \frac{N^2}{2EI}\,dx = \int_0^X \frac{N^2}{2EI} + \int_0^V \frac{N^2}{2EI}\,dv$$

where, of course, we have

$$V + X = l = v + x.$$

Now if M be the moment due to the weight of the rotor and m that due to the additional load applied at X, we have:

$$N = M + m \text{ and}$$

$$U = \int_0^X \frac{(M+m)^2}{2EI}\,dx + \int_0^V \frac{(M+m)^2}{2EI}\,dv$$

so that

$$\delta_X = \frac{dU}{dP}$$

$$= \int_0^X \frac{M + m}{EI} . \frac{dm}{dP} . dv + \int_0^V \frac{M + m}{EI} \frac{dm}{dP} . dv$$

$$= \frac{V}{l} . \int_0^X \frac{M+m}{EI} . x\,dx + \frac{X}{l} \int_0^V \frac{M+m}{EI}\,v\,dv$$

Now this expression holds whatever the value of P, and hence it will still hold if P = 0, in which case m is also zero.

Hence, finally, we get for the deflection at the point X of the rotor, under its own load, the expression:

$$\delta_X = \frac{V}{l} . \int_0^X \frac{M}{EI}\,x\,dx + \frac{X}{l} \int_0^V \frac{M}{EI}\,v\,dv \quad . \quad . \quad (1)$$

If $\frac{M}{I}$ be plotted for each point of the span we can obtain both of these integrals directly by means of the Amsler integrator. Unfortunately, this is an expensive instrument, and few offices are equipped with it. Where available, however, it provides in conjunction with the formula previously given much the simplest method of determining the critical speed of a complicated rotor.

Theoretically, if instead of plotting $\frac{M}{I}$ against x, we plotted it against x^2, we could determine the value of the above integrals by the ordinary planimeter, but the curve thus obtained is, with such a rotor, as is represented in Figs. 1 and 2, of an impracticably awkward character.

We can, however, proceed in another way, and thus obtain the value of the integrals by the use of the planimeter only. In general the value of I changes abruptly, but is constant for any particular section of a rotor. Thus for the rotor illustrated in Fig. 1 we may write:

$$\int_0^x \frac{M\,x}{I}\,dx = \frac{1}{I_A}\int_0^A M\,x\,dx + \frac{1}{I_B}\int_A^B M\,x\,dx + \text{etc.}$$

$$\text{Let } y = \frac{x^2}{I}, \text{ then } dy = 2\,x\,dx.$$

so that

$$\int_0^x \frac{M\,x}{I}\,dx = \tfrac{1}{2}\int_0^A M\,dy + \tfrac{1}{2}\int_A^B M\,dy + , \text{ etc.}$$

$$= \tfrac{1}{2}\left[\frac{x_A^2 - x_0^2}{I_A} M_A + \frac{x_B^2 - x_A^2}{I_B} M_A + , \text{ etc.}\right]$$

Where M_A denotes the mean value of M between 0 and A, and M_B the mean value between A and B.

Hence if M be plotted against y, areas of the curve will represent twice the corresponding integral

$$\int_0^x \frac{M\,x}{I}\,dx$$

We proceed as illustrated in the annexed table, the rotor being that represented in Fig. 1 *ante*.

Section.	x.	$100\,x^2$.	$\Delta\,100\,x^2$	I.	$\Delta\frac{100\,x^2}{I.} = 100\,\Delta y$	$100\,y = 100\,\Sigma\Delta y$.
O A	5·813	3,379	3,379	3·976	849·8	849·8
A B	16·969	28,798	25,419	12·565	2023·0	2872·8
B C	19·407	37,675	8,877	10,492	0·9	2873·7
C D	23·532	55,366	17,691	17,553	10·1	2883·8
D E	28·282	79,976	24,610	30·582	80·5	2964·3
E F	44·345	196,604	116,628	227·38	514·0	3478·3
F G	65·97	435,204	238,600	188·79	1270·0	4748·3
G H	68·22	465,497	30,293	1106·0	27·3	4775·6
H I	85·22	726,245	260,748	849·8	307·0	5082·6
I S	87·72	769,480	43,235	5812·0	7·51	5090·1
J L	92·47	855,070	85,590	5132·7	16·7	5106·8

In compiling this table the values of x^2 are taken from Barlow's tables. The fourth column is the difference between successive numbers in the third column, and these differences divided by I, give Δy as tabulated in column 6, and each entry in the seventh column is the sum of the preceding numbers in the sixth column, and gives the value of y against which has to be plotted the corresponding values of M. The curve thus obtained is shown in Fig. 3. Where the intervals between successive values are large as between O and A; A and B; F and G; intermediate values of y and M are calculated, but this is not necessary elsewhere. In this curve the area up to the vertical line $a\beta$ represents twice the integral

$$\int \frac{M\,x}{I} . dx$$

between 0 and $x = 27{\cdot}94$ in., this being the point at which the shear on the rotor if supported at the right hand end only would be one-quarter of the total shear. Similarly the area of the curve up to the vertical $\gamma\eta$ gives twice the value of the above integral between o and $x = 68$, whilst the area up the third vertical $\epsilon\mu$ gives twice the value of the integral between o and $x = 88{\cdot}11$ in.

The value of the integral $\int \frac{M\,v\,dv}{I}$ is found in a similar way, distances from the right hand support being tabulated instead of the left-hand support. It is not necessary in either case to carry the tabulation beyond some three-fourths of the span.

From these integrals the deflection at the points in question are then obtained by equation (1) *ante*.

Where an Amsler integrater is available it is, however, preferable to use it as rather less preliminary arithmetic is required.

Naturally in calculating critical speeds, any other of the formulæ for mean values given by Cotes can be used. Thus if we divide the shear into three equal parts instead of four, and calculate the deflections at the two intermediate points of division, we get

$$\omega^2 = 386{\cdot}4\,\frac{\delta_1 + \delta_2}{\delta_1^2 + \delta_2^2}$$

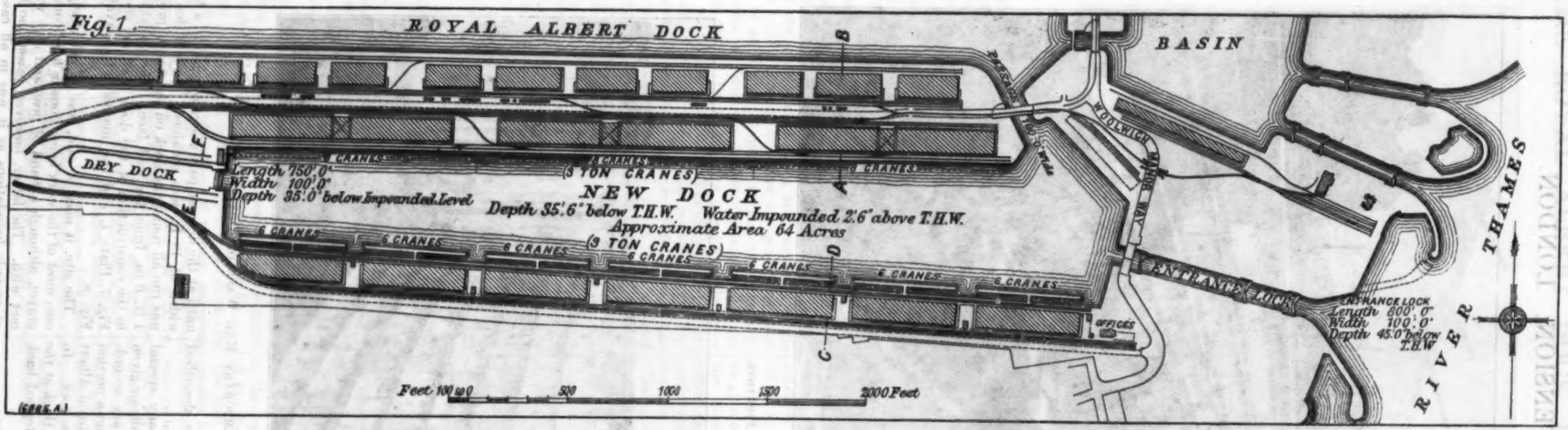
but the possible error made is, of course, smaller the greater the number of deflections used.

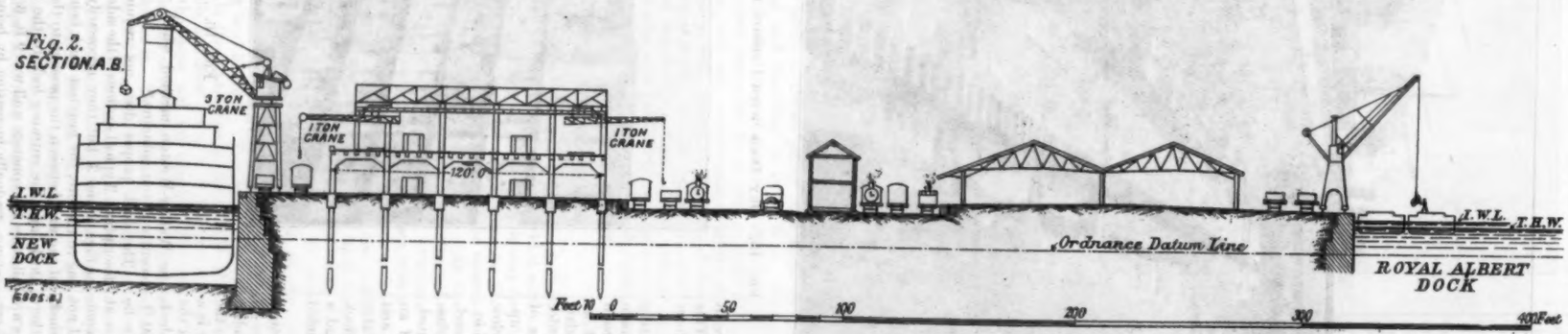
THE ROYAL ALBERT DOCK EXTENSION (SOUTH).

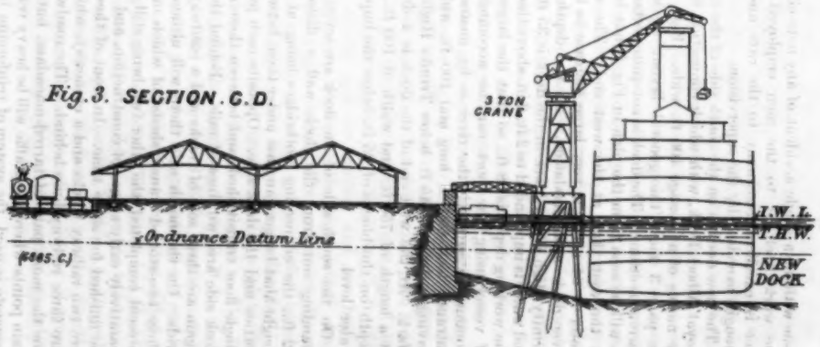
WHEN, on July 8, His Majesty King George opens the new dock which up till now has been officially styled the Royal Albert Dock Extension (South), a very notable addition to the accommodation of the Port of London will have been made. Altogether the added water area amounts to about 64 acres, with about 2½ miles of quay, the undertaking having been, we believe, the most costly single work constructed for the port, a sum approximate to 4,500,000*l.* representing the outlay involved. The work has long been projected; in fact, the powers under which the present undertaking has been carried out are extensions to those granted in 1901 to the London and India Dock Company. It may be remembered that in 1911 a large programme of dock development work was drawn up by the late chief engineer Mr. F. Palmer, C.I.E., M.Inst.C.E. In this programme, several portions of which have already been carried out, such as Mr. Palmer's suggestion for impounding water to a depth of 2 ft. 6 in., in order to allow for the increasing draught of sea-going vessels, the proposal was made for two large new docks in the Victoria and Albert Docks district. The smaller of the two it was proposed should be put in hand as early as possible, in order to provide facilities for larger vessels nearer to London than Tilbury. It is this dock which is now about to be opened, the work having been accomplished since the resignation of Mr. Palmer in 1913, under the supervision of his successor, Mr. C. R. S. Kirkpatrick, M.Inst.C.E., chief engineer to the Port of London Authority, Mr. A. Binns, M.Inst.C.E., having acted as resident engineer on the work throughout.

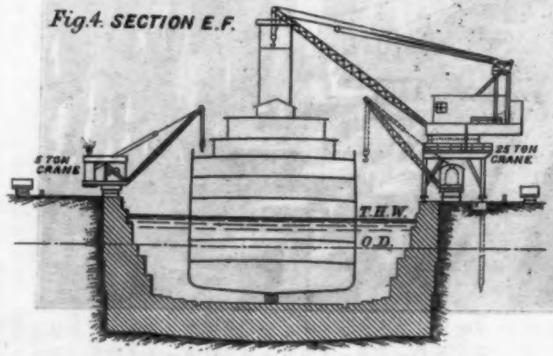
Begun in 1912, the work has been continued without actual interruption, though during the war it was curtailed to such an extent that for a long while the progress was slow. Messrs. Pearson and Sons, Limited, were the contractors for the main dock works, but in 1918 agreed to a termination of their contract and the construction has since been carried on by the Port Authority itself. The work has, we understand, been brought to a successful

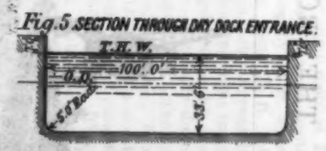
THE ROYAL ALBERT DOCK EXTENSION, LONDON.

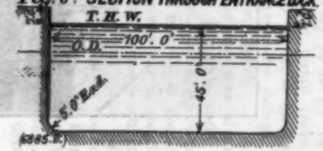












THE ROYAL ALBERT DOCK EXTENSION, LONDON.

FIG. 15. DRY DOCK WITH CAISSON IN POSITION.

issue without a single accident of any note either to the work itself or to the men employed. This fact is excellent testimony to the care and forethought exercised by the supervision.

The new dock is on the south side of the existing Royal Albert Dock, with which connection is made by means of a passage 100 ft. wide. Figs. 1 to 6 on page 3 show the general layout as well as various sections. The dock is not quite rectangular, as will be seen from the plan in Fig. 1, but is wider at the east than at the west end. The area of water is 64 acres, a very large increase to the up-river dock accommodation. As the depth below Trinity High Water Mark in the dock is 35 ft. 6 in., and water is impounded to 2 ft. 6 in. above that level, the working depth is 38 ft., so that the largest class of vessel using the port can be accommodated. Communication with the river is by means of an entrance lock 800 ft. long and 100 ft. wide, and having a depth of 45 ft. below Trinity High Water Mark. At the west end of the dock is a dry dock of a length of 750 ft. and width of 100 ft., and a depth on the blocks of 35 ft. below the impounded water level.

On the south side of the dock are seven jetties standing out from the dock wall a distance of 32 ft., the connecting footbridges being at such a height that barges can pass under them between the jetties and the dock side. Opposite each jetty is a single floor transit shed, and between these and the dock side are two lines of rails. Behind the sheds again are three sets of tracks and a roadway 30 ft. wide. On the north side there will ultimately be three two-storied transit sheds, of which one is at present completed the other two being still in comparatively early stages of construction, and will not be finished for some time. In front of these sheds are two railway tracks and a craneway, while there are three railway lines behind. The roadways are for the most part of tarred-macadam, but at certain points where the traffic will be heavy reinforced concrete is used, the system of reinforcing being on

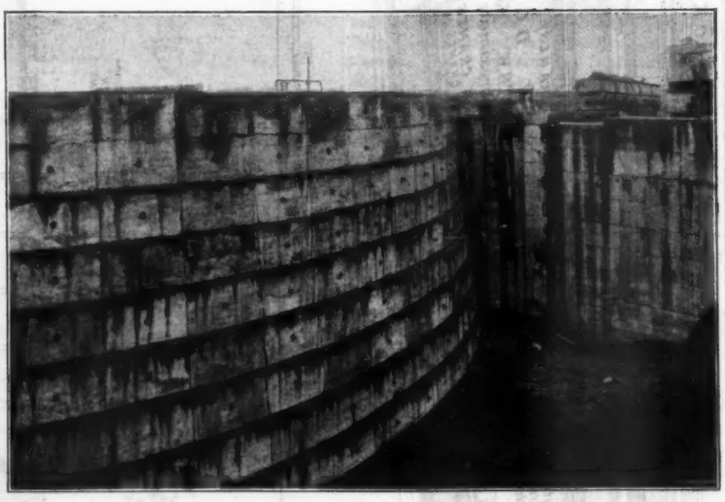


FIG. 16. TEMPORARY END WALL OF DRY DOCK.

the Walker-Weston method which was described recently in our columns.*

The dock proper does not require any special description. Typical sections of the side walls are given in Figs. 2 and 3, but they necessarily vary according to the site, the heaviest work being on a portion of the wall between the passage to the Royal Albert Dock, and the entrance lock to the new dock. In all cases the concrete wall was 9 ft. 6 in. thick at the coping, gradually increasing by being stepped back until at the deepest part above referred to a bottom width of 19 ft. was obtained. In addition a toe was run all round the dock on the inside, projecting 4 ft. 6 in. from the wall face. The goliaths used in the construction of the dock wall are shown in Fig. 7, Plate I, and the manner of excavating in Fig. 8.

The site, it may be said, was an extremely good one, most of the work being done in hard compacted gravel, although a band of peat and clay was also met with. The latter, however, caused no trouble as regards foundations as it was in all cases well

* See ENGINEERING, vol. cxi, page 169.

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

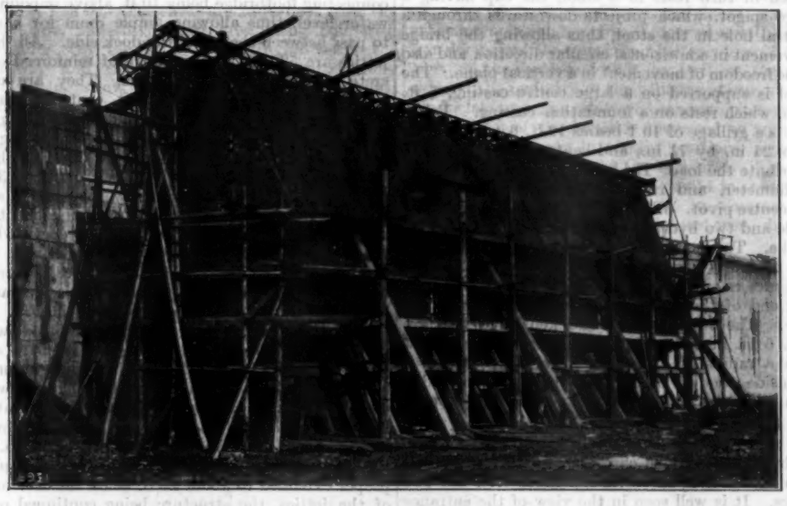


FIG. 17. THE CAISSON FOR THE DRY DOCK ETC.

above the foundation level of all the heavy work, and was therefore cut right through. The aggregate for the concrete work was all obtained from the gravel on the site, while a good deal of this material was used on the southern portion of the area, which required raising considerably, the present roadway level on this side being about 10 ft. above the original formation level.

THE ENTRANCE LOCK AND WING WALL JETTIES.

The entrance lock has a width of 100 ft., and a total length between gates of 800 ft. It is provided with one inner pair of gates, and two pairs at the river end. In addition there are grooves on each side of each pair of gates to facilitate the construction of dams for de-watering any section for repair work. By means of a caisson at the inner end of the lock the usable length can be increased to 910 ft. should this be necessary. The concrete of the lock walls is 10 ft. wide at the coping, increasing with the depth to a normal section of 21 ft. thick at the bottom, though this is increased to considerably more at certain points. At intervals of about 50 ft. there are buttress piers on the outside. On the normal section the thickness of the invert is 11 ft. 9 in., the upper surface of the section being struck to a radius of 200 ft. The coping is of granite throughout. A transverse section at the gate recess shows a thickness of concrete of 16 ft. 6 in. in the floor, which at this point is straight. The greatest width at the gate recesses is 120 ft. The depth of water over the sills, as already stated, is 45 ft. below Trinity High-Water Mark, which is increased to 50 ft. 3 in. at the normal section between the gates, giving 52 ft. 9 in. depth with impounded water. The concrete used in the inverts was 6 : 1 and in the side walls 8 : 1, the latter being given a 6-in. facing of 3 : 1 concrete. A view of the entrance lock during construction is shown in Fig. 9, Plate II. The view is taken from the river end, and shows the curved entrance walls and the two pairs of gates. The appearance of the gates when practically complete is shown in Fig. 10.

Two subways of oval section 3 ft. 6 in. by 6 ft. 6 in. for the diversion of sewage pumping mains pass below the lock. There are also four others for water mains, &c. These are 6 ft. in. diameter, and are constructed of cast-iron segments of a length of 4 ft. The shafts are also 6 ft. in diameter. Fig. 12, Plate III, illustrates a pair of gates looking on their convex sides, and Fig. 11 shows a general view of the entrance lock when filled with water. The bascule bridge carrying the roadway is well illustrated.

The wing walls extending from the lock to the river have a width of concrete at the top of 6 ft., widened to various sections below, the greatest being 23 ft. 6 in., with a toe of 6 ft., giving a total width at the base of 29 ft. The toe is run up into the wall with a radius of 7 ft. 6 in. The extension to these walls is of ferro-concrete sheet piling, using piles 14 in. by 14 in., tied back every 10 ft. to a ferro-concrete anchorage set about 60 ft. back from the wall face. The 14-in. by 14-in. piles used were reinforced with four bars, 1¼ in. in diameter and stirrups, &c., of ⅜ in. section.

The wing walls are extended on both sides of the entrance by jetties of timber piling, with 12-in. by 12-in. waling, and sheathing 12 in. by 6 in. On the north side the jetty is prolonged sufficiently to give complete protection to as long a vessel as the entrance lock will accommodate, before she enters the actual lock. Much of the piling of these jetties consists of double 14-in. by 14-in. piles, bolted together and driven by a 6-ton steam monkey. These double piles were fitted with a special form of shoe to take the ends of both piles. All drilling on these jetties was done by compressed air.

THE DRY DOCK.

The dry dock at the west end of the main dock is, as already stated, 750 ft. long. It is provided with a caisson for closing the entrance, which, it may be stated, may also be used for the passage to the Royal Albert Dock. A view showing the caisson in position is given in Fig. 15, page 4. At the back end the dock is finished with a circular wall, worked into the side walls, the latter, however, being carried straight on for some distance with a view to future lengthening. Fig. 16 shows a view taken from the outside of the curved end wall, illustrating the continuation of the side walls for the purpose mentioned. The dock width is 100 ft.; the normal side wall section being 8 ft. wide at the top, increasing to 20 ft. 6 in. at the bottom. The side walls are stepped back in stages of 3 ft., 2 ft. 6 in. and 2 ft., so that the total width at the coping level is 125 ft. The normal thickness of the floor in the centre line of the dock is 16 ft. The side walls and floor are of 8 : 1 concrete with granite for the steps and top coping. The semi-circular end is built of concrete with 1-in. reinforcing rods embedded in it. The thickness is 3 ft. at the top, extending to 6 ft. at the base. A capstan pit is arranged in this wall on the dock centre line. The dock is provided on each side with two sets of stairs and slides, leading to the dock floor. The entrance to these is by 10-ft. by 6-ft. openings on the ground level. A drainage culvert, 7 ft. wide and 7 ft. high is arranged about 50 ft. from the entrance, connected with the pump room. In addition a pipe subway 6 ft. in diameter passes under the dock. The filling culverts are 6 ft. in diameter. The intake well below the pump room is 37 ft. by 12 ft. by 14 ft. high inside measurements. The pump room is 93 ft. long by 31 ft. wide and 24 ft. 6 in. high, the floor being 7½ ft. below ordnance datum, or 22 ft. 6 in. below impounded water level.

The pumping plant consists of two sets of twin centrifugal pumps by Messrs. Drysdale and Co., Glasgow, electrically driven by alternating-current motors of 820 h.p. The pumps have 48-in. suctions and 54-in. deliveries. Each pair works in parallel, and delivers into a combined discharge which is fitted with an hydraulically operated sluice valve and a reflux valve. The discharge pipes are bell-mouthed in the dock wall. There are also in the pump room two drainage pumps for dealing with the water entering the dock when dry. These have 8-in. suctions and 12-in. deliveries, and are direct-driven by small electric motors.

THE CAISSON AND LOCK GATES.

The caisson, which can be used either for the dry dock or the passage leading to the Royal Albert Dock, has an extreme length of 102 ft. 6 in., and rests in recesses 103 ft. wide in the masonry, the width of the locks, &c., being standard to 100 ft. between side walls. It is shown in course of construction in Fig. 17, annexed. Its extreme depth is 41 ft. 9 in., and extreme breadth of the steel structure is 28 ft. 6 in. It is provided on the top with a gangway 12 ft. 6 in. wide. Commencing at the keel, which has a width of 1 ft. 6 in., the section quickly expands to the full width of 28 ft. 6 in. at a height of 10 ft. 6 in. The next section has a height of 10 ft. 10 in., with vertical side walls; thereafter the section is gradually reduced until at a further height of 17 ft. 11 in. the width is 14 ft. The gangway is at a level of 2 ft. 6 in. above this. The frames are spaced approximately 1 ft. 11 in. apart. Ballast is placed in the bottom, above which are compartments for water ballast, air chambers, &c. There are two watertight bulkheads across the caisson, as well as watertight decks. There are two main 42-in. sluice valves operated hydraulically, with sluice pipes of the same size extending from the sides to the valves which are placed on the centre line of the caisson. The water is removed from the interior by ejectors. The keel and stems are fitted with greenheart timber, and fendering is provided in two belts at the greatest cross-section, and above. That at the belt is 10-in. by 10-in. elm, while above, verticals of 10 in. by 4 in. are laid on horizontals of 10 in. by 4 in. Stirrups are provided in the dock wall to fix the caisson in position. These are attached to anchor bars embedded in the concrete. The stirrups are worked by bevel and screw gear. They are fastened over projecting castings on the caisson stems, below which is a greenheart wedge block corresponding to a wedge fixed on the wall side. Hydraulic connection with the dock sides is made by means of flexible jointed pipes. The scuttling tank is emptied at a rate of 8,000 gallons per hour. The top tank may be filled by the ejectors, but is emptied by gravity into the end chambers.

The lock gates are interchangeable. They are well illustrated in Fig 12, Plate III, and in other views. The hinge centres are set back 2 ft. 6 in. from the lock wall and the radius of the roller path is 48 ft. Figs. 10 and 11 already referred to, give a good idea of their general appearance. They are 7 ft. 2¾ in. wide at the greatest section and are built up of ⅜-in. skin plating with angle lattice frames and watertight decks. The gates are operated by an opening lever of plate girder construction working on the hinge pin at the heel, and having a cast steel nose held in a plate frame placed across the top of the gate. The heel-post pin for the operating lever is 9 in. in diameter. The rollers are 3 ft. in diameter, carried in housings pivoted to the gate at one end and with slight vertical adjustment at the other, fitted with spring shock absorbers. The pintle is 1 ft. 11 in. in diameter, by 9 in. deep, and works in an anchor strap of 6-in. square section, held in a casting which is anchored back to the lock side in three directions. The bottom pivots and sockets consist of inverted spherical bearings, the socket having an internal

diameter of 7 in., and working on a pin 9½ in. high. The hydraulic cylinders working the leaves have a stroke of 12 ft. 10½ in. The caisson and lock gates, &c., were supplied by Messrs. Sir William Arrol and Co., Ltd.

The Passage to the Royal Albert Docks and Swing Bridge.

The connection with the Royal Albert Dock is made by a passage 100 ft. wide, over which is a swing bridge. No gates are provided at this passage, but two sills are arranged so that the dry dock caisson can be used against pressure from either side. The swing bridge and roller path are on the west side of the passage. A subway 6-ft. diam. extends under the floor of the passage, having 6-ft. diam. shafts on each side communicating with the surface.

The swing bridge across the passage between the Royal Albert Dock and the new dock being on the skew spans a gap of 108 ft., its appearance when practically complete being shown in Fig. 13, Plate IV. It was built by Sir William Arrol and Co., Ltd., Glasgow. The pivot of the bridge is set back 26 ft. 6 in. from the side wall, and the nose projects 13 ft. 3 in. over the far wall. On the centre line the projecting span is thus of about 150 ft. The heel or back extension has a length of 50 ft., so that the whole bridge is just over 200 ft. in length. It carries a roadway 20 ft. 8 in. wide, on one side of the centre of which is laid a railway track connecting with the outer of the three lines along the north side of the north transit sheds. On either side of the bridge, outside the main girders, is a footpath. The main girders have a height between centres of top and bottom chord, at the panel over the pivot, of 22 ft. 6 in., and at the nose of 13 ft. 6 in. At the end of the back extension the centres of the chords are 16 ft. 6 in. apart. The main girders are divided into 13 braced panels, with plate panel sections at either extremity. The majority of the braced panels are 13 ft. 7 in. between centres of verticals on the span proper, with 14-ft. panels on the counterbalance side. The main verticals over the pivot are centred 10 ft. apart. The plate panel section at the toe is 4 ft. 10 in. wide, and at the counterbalance end 14 ft. 6 in. The main girders are centred 26 ft. apart, and the overall width of the bridge is 39 ft., which, allowing for the footpaths, girders and curbs, gives a roadway width, as stated, of 20 ft. 8 in. The top chord is 2 ft. 8 in. deep at its greater section, tapering to 2 ft.; the bottom chord is 2 ft. deep and 3 ft. wide. The chords consist of two ¾-in. plates with double flanges of 8-in. by 4-in. by ⅝-in. angles, the plates being 2 ft. 2½ in. apart where single plate webs are used, or less where the webs are compound. Cross-bracing outside the top and bottom flanges of each chord is of 3½-in. by 2½-in. by ½-in. angles. The verticals are for the most part composed of plates and angles forming facing channels with cross-bracing of angles. The diagonals are similarly arranged. Both verticals and diagonals have in the case of members near the centre a central stiffening plate web. Cross and wind-bracing is carried over the top chords.

The kentledge box at the heel end of the bridge is 6 ft. deep and 14 ft. 6 in. long. It is built up mainly of ½-in. and ⅜-in. plating with angle irons ranging from 8 in. by 8 in. by ½ in. to 7 in. by 7 in. by ⅝ in. It has three cross-diaphragm stiffeners of the full depth and width of the box.

The main floor cross-girders are of I-section and are just over 2 ft. deep by 1 ft. 6 in., the flanges being composed of ½-in. plate. The secondary longitudinals are 1 ft. 6⅛ in. deep and 8⅜ in. across the flanges. The flooring is laid with buckle plates, ¼ in. thick, and about 4 ft. 3 in. by 3 ft. 6 in. The centre frame over the pivot is composed of plate and angle, the section immediately below the main girders being 2 ft. 10 in. deep, below which are four large plate cross-girders, 5 ft. 7 in. deep, strongly braced with plate and angle diaphragms. The deep girders have 1-in. plate for the main webs, while two 8-in. by 8-in. by 1-in. angles form the flanges.

The pivot centre consists of a half-cylinder and cup, carrying a large crosshead with 5-ft. arms, from which are suspended, at either end, two suspension links riveted to the cross-girders of the main centre frame. The cylinder is carried in a cup, which in turn rests in a stool, the cup having a large spigot, which projects downwards through a central hole in the stool, thus allowing the bridge movement in a horizontal circular direction and also some freedom of movement in a vertical plane. The stool is supported on a large centre casting, 5 ft. high, which rests on a foundation casting. Below this is a grillage of 16 I-beams 12 ft. 6 in. in length, each 24 in. by 7¼ in., and centred 9 in. apart, to distribute the load. The balance rollers are 3 ft. 6 in. in diameter, and run on a path 11 ft. 6 in. from the centre pivot. Slewing is performed by means of cable and two hydraulic cylinders with 10-ft. 1½-in. stroke. The centre of the rope circle for operating the bridge is struck to a radius of 17 ft. 0⅜ in. Tail presses and wedging blocks are provided at the heel end of the bridge, and bearing plates at the nose. The rollers under the kentledge box are 3 ft. 6 in. in diameter, and run on a path struck with a radius of 47 ft. 3 in., from centre pivot to inside edge of path. The bridge is provided with hydraulic buffers.

The Bascule Bridge.

The bascule bridge carrying the deviated Woolwich Manor Way over the entrance lock has two leaves. It is well seen in the view of the entrance lock, Fig. 11. The lock, it will be remembered, is 100 ft. wide. The pivots are set back on either side from the lock side a distance of 14 ft. 6 in., making a total distance between pivots of 129 ft. The head-room when the bridge is down, above impounded water level is 14 ft. The roadway provided is 17 ft. 6 in. wide, with two outside footpaths extending 7 ft. 4 in. from the centre of the main girders. The total overall width is 37 ft. 2 in. The main bearings are 14 in. in diameter. The greatest height between the centres of the top and bottom chords is 17 ft. 9 in., though at the junction of the balance-box and rack with the top chord the steelwork projects slightly higher than the chord itself. Each bascule is formed of eight panels, tapering in height to the centre of the bridge, where the centres of the top and bottom chords are 4 ft. 6 in. apart. The radius of the rack is 22 ft. 3 in., and the heel girders are 25 ft. 3 in. long. The main top chord has a section of about 1 ft. 2 in. by 2 ft. 2 in., made up of plates and angles, built into double girders back to back, with a 1-ft. 6-in. space between the vertical webs. The bottom chord is very similar. The main verticals over the pivots are of H-section built up of plates and angles, and are 1 ft. 8 in. overall by 1 ft. 9⅜ in.

At intervals of 10 ft. 7⅜ in. centres there are attached to the underside of the bottom chord cross box-section girders 10½ in. deep by 1 ft. 5½ in. at the side, deepening to about 1 ft. 9 in. at the centre. Between these there are intermediate cross-girders. The flooring is of buckle plates, generally measuring about 4 ft. 6 in. by 3 ft. 9 in. The buffer-box is rectangular and is 3 ft. deep, built up mainly of ½-in. plate and 4-in. by 4-in. by ½-in. angles.

The heel girders have a depth, below the main pivots, of about 4 ft. 10¾ in., this being reduced at the outboard end to about 2 ft. 0¾ in. These girders are of plate, 1 in. thick, with top and bottom built-up flanges 1 ft. 1 in. wide of plate ¾ in. thick. The heel girder rocker bearings are 5 in. in diameter. The quadrant has teeth set at a circular pitch of 5 in., the driving pinion having a circular pitch diameter of 28·66 in. Air buffers are provided in the pit, consisting of cylinders 1 ft. 2 in. in diameter with a piston having a stroke of 1 ft. 7½ in. The bridge is provided with locking bolts operated by electric motors of 2 brake horse-power. The main motors are of 50 brake horse-power; they are totally enclosed, direct current, series wound, reversing, for 460 volts. The bridge opens in 60 seconds against no wind or in 75 seconds against a wind giving a pressure of 15 lb. per square foot. The weight of each leaf is 190 tons without counterweight, the latter amounting to 177 tons. The total weight on the trunnions for each leaf is 368 tons.

The bridge was constructed by Messrs. Sir William Arrol and Co., Ltd., Glasgow.

The South Side Crane Jetties.

The seven crane jetties on the south side of the dock stand 32 ft. away from the dock side, the connecting footbridge being 10 ft. above impounded water level, thus allowing ample room for barges to pass between them and the dock side. All these jetties are 520 ft. long, and are of reinforced concrete on the Considère system. They are constructed of pile trestles set 10 ft. centre to centre in a longitudinal direction, the piling being in three longitudinal rows, of which the spacing at ground level is slightly less than 12 ft. The three rows merge into two at the top deck, centred 13 ft. 6 in. apart. This is arranged by the outside and the centre rows being inclined towards each other and meeting at the front of the top deck, while the rear row is driven practically parallel with the centre row. A view of the jetties under construction is given in Fig. 19, page 16, the appearance of a finished jetty being illustrated in Fig. 20. All the piles are 19 in. by 19 in., fitted with pile shoes, and reinforced by eight 1-in. bars and ⅜-in. diameter spiral of 2½ in. pitch, gradually lessening to 1-in. pitch at the head. The piles were driven to a depth of about 13 ft., and their greatest length was 37 ft. 3 in., these being in the front or outboard row. This gave about 15 ft. 6 in. in the ground for these particular piles. The piles proper extended to about 20 ft. below the deck level of the jetties, the structure being continued over them in reinforced concrete.

At levels, 11 ft. 3 in. and 19 ft. 9 in. below the deck there are horizontal longitudinal and cross braces. The latter are of 16 in. by 20 in. section and the former are 18 in. deep by 25½ in. wide. Diagonal strutting in the direction of vertical planes across the jetty is inserted at each trestle running from the back row at the ground level to the centre row about half-way up to deck level, and again from the back row at the level of the lower horizontal bracing to the point of juncture of the two front rows just below the deck level. In addition to this bracing certain of the trestles are braced together by two systems of panels of crossed braces. This bracing is provided between the back row piles between five trestles at either end of the jetty, and five in the centre, making in each case two sets of vertical pairs of cross-braces at each place. At these points, also, horizontal cross braces are arranged at the level of the main lower horizontals.

As an interesting feature of construction it may be mentioned that the lower back struts between the back and centre rows of piles are 14 in. by 14 in. and were pre-cast with a large eye at the lower end to fit over the 19 in. by 19 in. piles after driving the latter. These eyes had a width of 33 in. and depth of 24 in., the ring being reinforced with four bars, ⅞ in. in diameter and with short upright lengths of ⅜ in. bars with ⅛ in. spirals of 2 in. pitch. When placing these struts the concrete on the main piles was hacked away and this space, including 1 in. clearance in the eye was grouted up.

The decking is 20 ft. 3 in. wide and is carried on transverse beams at the top of the trestles, 3 ft. 5 in. deep, of which 5 in. represents the actual floor thickness. These transverse beams have a width of 18 in. Between the trestles extend two main beams, 12 in. wide and 25 in. deep below the floor, and two inside secondary longitudinal beams, 7 in. by 11 in. deep. The front and back edges of the deck are formed by coping beams 8 in. wide and 1 ft. 10 in. deep, the tops of which stand 4½ in. above the floor level. All these parts are reinforced. The decking proper is 5 in. thick reinforced with top and bottom bars, ⅝ in. in diameter with distance and clamp bars ¼ in. in diameter. Timber fendering is provided extending approximately 18 ft. from the coping beam level downwards. This is built up on 12-in. by 12-in. longitudinals in three strings, one at the coping, one at the upper horizontal bracing level, and one 2 ft. 6 in. above the level of the lower horizontals. The fendering proper consists of 9-in. by 9-in. verticals spaced 11 in. apart. The deck is laid with 50 lb. rails for the travelling cranes, protected on either side by guard angle irons.

The South Side Transit Sheds.

The seven transit sheds on the south side are each 528 ft. long and 120 ft. wide. They are

steel and sheet buildings of two spans, each 60 ft. In addition, on the side furthest from the dock is a 10-ft. verandah. The floor level of the sheds runs up from the dock coping level on a grade of 1 in 40. The sheds are 25 ft. back from the dock side, the intervening area being laid with concrete. On the south side of the sheds the roadway and railway tracks are approximately 3 ft. 6 in. below the shed floor level. The shed columns are placed on base blocks of concrete on the heads of ferro-concrete 12-in. by 12-in. piles. The steel trusses are spaced 12 ft. apart down the sheds. The head-room to the bottom chord of the roof trusses is rather more than 12 ft. 6 in., but at the sides this is reduced to about 10 ft. by ties carried down to the columns. The column spacing

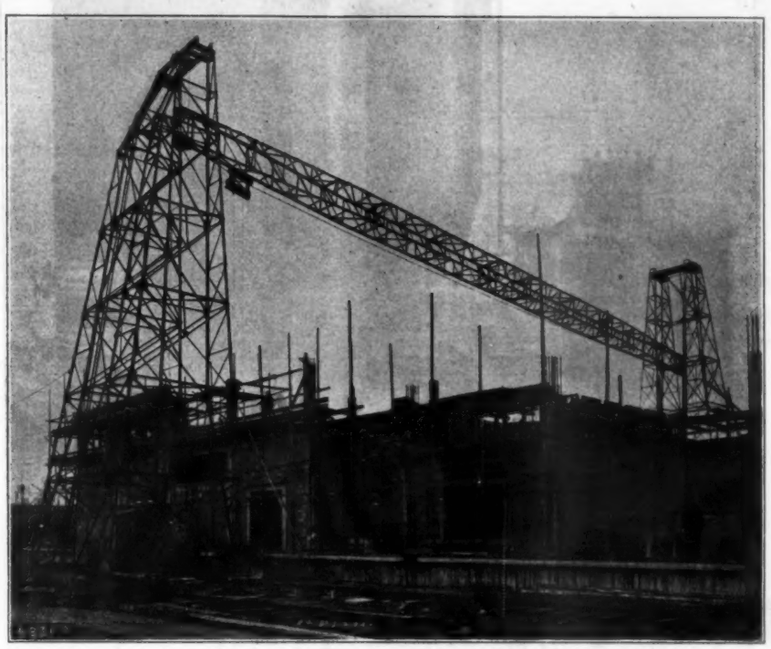


FIG. 18. WALKER TRANSPORTER CRANE USED DURING CONSTRUCTION.

in a longitudinal direction is 24 ft. The sheds are walled with galvanised iron and have 10-ft. 6-in. doorway openings, and roof glazings.

THE NORTH SIDE TRANSIT SHEDS.

The transit sheds on the north side quay are double-storied buildings of reinforced concrete framework with brick wall filling. The eastern shed is complete, but the central and western sheds will not be completed for some time. They are, respectively, 1,100 ft., 1,150 ft. and 1,100 ft. in length, in order from east to west, and are all 120 ft. wide on the ground floor and 110 ft. wide on the first floor, there being a 10-ft. balcony on the first floor level on the south or quay side of the building. Each shed is divided into four by brick fire divisions. On the ground floor these result in approximately four sections of 250 ft. length each with a central area 100 ft. in width arranged as a covered cart area. The exact lengths vary, of course, with the sheds, as these are of different lengths. On the upper floor the buildings are divided into two sections of 300 ft. and two of 250 ft., the central partition wall being carried on girders supported by a line of large columns in the cart area. The ground floor is at quay level on the south side, but on the north side it is 3 ft. 6 in. above the level of the railway lines which run alongside.

The columns on the ground floor supporting the upper storey are spaced at about 24-ft. intervals across and 25 ft. down the building, except for the cart area, where the line of central columns is 50 ft. from the partition wall on either side, and the columns themselves are about 12 ft. centres, except for two which are about 35 ft. centres. The columns in the partitions bounding the cart area are also spaced about 12 ft. centres. On the upper floor the columns are spaced at approximately 50 ft. intervals lengthwise and 24 ft. intervals crosswise of the shed. The ground floor is provided with an ample number of 10-ft. doorways with sliding iron doors, and the upper floor has openings 25 ft. by 10 ft. on the south and 22 ft. by 10 ft. on the north sides. The majority of the columns stand on base blocks laid over two reinforced concrete piles, though the number of the latter is increased to groups of three, four and six in certain positions, especially for the main columns of the cart area. The piles used were 35 ft. long and 14 in. by 14 in., reinforced with vertical corner bars 1¼ in. in diameter, and links ⅜ in. in section with cast-iron diagonal struts. The reinforcing of the beams is for the most part of 1½-in. bars, with 1 in. by ⅛ in. stirrups and binding. The ground floor is laid with 6 in. of concrete. The depths of the ground floor beams varies according to position and runs up to 33 in. in the end walls. The ground floor columns are normally 19 in. by 19 in., reinforced with eight vertical rods 1¼ in. in diameter, with ⅜ in. links and tiers. Angle-iron guards of 4 in. by 4 in. by ½ in. are let into the concrete on all isolated and projecting columns at the corners, to a height of 3 ft. 6 in.

The large isolated columns in the cart area stand on groups of six piles, and have concrete bases 7 ft. 6 in. by 4 ft. 9 in. These columns are 2 ft. 6 in. by 2 ft. 6 in., and are reinforced with 36 vertical rods, 1¼ in. in diameter. The upper floor beams are normally 34 in. deep by 19 in. in width, with secondary beams spaced at 4 ft. 9 in. centres, 24 in. by 12 in., the intervening flooring being 4 in. thick, reinforced. The main trusses, of reinforced concrete, carrying the floor over the cartway area for the 35-ft. span mentioned above, are 6 ft. 7 in. deep, with top chord of a section 15 in. by 21 in. wide, and bottom chord of a section of 9 in. by 21 in. The diagonals vary from 9 in. by 21 in. at the ends, to 21 in. by 21 in. for two diagonals running into the base of columns on the top floor. The longitudinal beams extending over the cartway from the central line of columns to the partitions, and of 50 ft. span, are normally of a depth of 5 ft. 7 in., made up of a top chord 15 in. deep by 18 in. wide and a bottom chord of 9 in. by 18 in., with diagonals varying from 6 in. by 18 in. to 15 in. by 18 in. At the central line of columns these beams are deepened considerably, the bottom chord being gradually lowered till at this point the beam has an added depth of 2 ft. 3 in. These lengths of the bottom chords, and the diagonals immediately running out of them have a section 18 in. by 18 in. The main reinforcement through these beams is of 1½-in. bars.

The roof consists of north lights with four main longitudinal girders, and two vertical lights for each normal span of about 24 ft. The upper floor is 18 ft. 8 in. above the ground floor, and from the upper floor to the roof girders is 20 ft. 3½ in. The upper floor of each shed is provided with two underhung cranes of 1 ton capacity, by Messrs. Ransomes and Rapier, Ltd., of Ipswich. These are of 50 ft. span and run on gantries across the sheds, the rail level of which is 17 ft. 2½ in. above the top floor level. The gantry girders are 1 ft. 8 in. deep. These cranes can work over floor space on either side of their runways, and out over the side of the buildings at the ends of the gantries. The gantry girders have maximum spans of about 24 ft. They are built up of 18-in. by 7-in. by 75-lb. rolled steel joists, with 12-in. by 3½-in. by 26·1-lb. channels on the upper side, and 56-lb. bridge rails laid on the top. The cranes are electrically driven, and have a radius of 26 ft. Fig. 18, annexed, illustrates the Walker transporter crane used in the construction of the north side transit sheds.

THE CRANE EQUIPMENT.

The crane equipment on the south side comprises six 3-ton travelling cranes on each of the seven island jetties. These cranes are of the luffing type with a radius of 60 ft. with maximum load, or 65 ft. with a slightly reduced load, and are worked by electricity. The north side of the dock is served by 24 cranes of a similar type, thus allowing eight for each shed of about 1,100 ft. long. The appearance of a set of these cranes during erection is shown in Fig. 14, Plate IV. The dry dock is served by two cranes, one is a 25-ton electric crane with a radius of 80 ft., which is sufficient to extend over the centre line of the dry dock. This crane can travel down either side of the dry dock. A further 5-ton steam locomotive crane is provided at the dry dock, capable of passing between the legs of the 25-ton crane, and also able to work all round the dry dock. This crane has a radius of 37 ft. 6 in.

The cranes for the quays and jetties are being supplied by Messrs. Stothert and Pitt, Limited, Messrs. Ransomes and Rapier, Limited, and Messrs. Babcock and Willcox, Limited; those at the dry dock, the wall cranes and the underhung jib cranes at the transit sheds, by Messrs. Ransomes and Rapier, Limited, and the runabout electric cranes by the Chatteris Engineering Company, Limited.

MACHINERY AT THE ROYAL AGRICULTURAL SHOW.

THE eightieth Annual Show of the Royal Agricultural Society was opened at Derby last Tuesday. This is the fourth year in the history of the Society that Derby has been selected for the function, the previous occasions having been in 1843, 1881 and 1906 respectively. In both the latter years the Exhibition was a financial success, and in view of the importance of the work which the R.A.S.E. performs for agriculturalists and for the engineering firms whose products are used in agriculture, it is sincerely to be hoped that financial success will again attend the Derby meeting. At the time of writing it is too soon to form any estimate of the patronage the Show is likely to receive this year from purchasers or from the general public. Exhibitors, however, have not been deterred to any appreciable extent by the prevailing conditions of trade. The live stock on view number in the aggregate 3,613 head, exclusive of poultry and rabbits, a total well in excess of the corresponding entries last year at Darlington, when the previous record was established. It is, however, with the machinery and implement section, that we are mostly concerned. It might have been anticipated that the restricted railway facilities from which the country is suffering, together with the reluctance of firms to undertake expenditure which is not absolutely necessary at the present moment, would have had a serious effect

upon the display of machinery. But these causes are no doubt offset by the anxiety of manufacturers to secure orders to keep their works running, and their natural desire to be represented at their accustomed stands is probably reinforced by the feeling that in the present state of trade they can hardly afford to be absent from the leading Exhibition of its kind in the country. Be this as it may, the fact remains that the Implement Yard contains 508 stands, a number only exceeded by the Bristol Show in 1913, when there were five stands more. The area covered by machinery sheds at Derby is 13,990 sq. ft., exclusive of open ground spaces, and this again is almost a record figure, having only been exceeded twice in the last 10 years.

It will be gathered that, in spite of the somewhat adverse conditions under which it is being held, the Derby Show need not fear comparison with its predecessors, so far as the machinery on view is concerned. There are no noticeable omissions in the list of manufacturers exhibiting, and all classes of agricultural and allied machinery are well represented. As at Darlington last year, the dominant feature is the popularity of the internal combustion engine, whether driven by petrol, gas or oil. These engines have not only supplanted the steam engine almost entirely for general purposes, but have been applied to innumerable purposes for which steam plant is impracticable. Steam still holds its own for the heavy traction engine almost without competition, while the steam road tractor and steam wagon are retaining and possibly increasing their ascendency for their special classes of work, but the portable steam engine has almost been driven from the field in which it was formerly supreme, and the stationary steam engine may be said to have vanished entirely, so far as agricultural uses are concerned.

Suction gas plants are fairly represented, six or seven different makes being on view, and several being shown in operation driving engines. They range in size from 65 b.h.p. to 2 b.h.p., the former being built by Messrs Davey, Paxman and Co., Limited, of Colchester, and the latter by the National Gas Engine Company, Limited, of Ashton-under-Lyne, Lancashire. Both of these are constructed for wood fuel, the former utilising saw mill refuse, bark, shavings, &c., and the latter making gas from charcoal. We illustrate the Davey, Paxman producer plant in Fig. 1, annexed. The body of the generator, which is about 5 ft. diameter outside, is made of steel plate lined with firebrick. The fuel feeding hopper has a sliding door at the top, and a hinged and counter-balanced dumping door at the bottom, so that fuel is charged into the generator without the admission of air. The doors close on machined faces, as do also the generator doors. The latter have no loose crossbars or wedges, but each is carried by a malleable iron hinge and is kept tight by central pressure and fastened by a wing nut.

The gas from the generator traverses three cooling chambers in series and then passes through a centrifugal tar extractor on its way to the scrubber. The cooling chambers are vertical hollow pipes, each fitted with a water spray at the top. The tar extractor runs on ball bearings, and is driven by a belt or motor as desired. The scrubber contains wooden grids supporting layers of sawdust and shavings through which the gas rises, emerging in a cool and clean condition and passing away to the engine from the centre of the top of the scrubber. The plant in question will make sufficient gas to develop 65 b.h.p., the fuel consumption being from 2½ lbs. to 3½ lbs. per b.h.p. hour, depending on the quality of the refuse wood. It is stated by the makers that wood generally contains sufficient moisture to make gas without the vaporisation of additional water, so that no vaporiser is normally fitted. If, however, it is desired to use coal or coke as fuel, the first of the cooling chambers is replaced by a vaporiser to provide the necessary steam.

The gas engine, illustrated in Figs. 2 to 6, on the present and opposite pages, is also of Messrs. Davey, Paxman and Co.'s manufacture. Its cylinder is 12½ in. bore by 10 in. stroke, and when running at 220 r.p.m. the engine will develop a maximum of 52 b.h.p. on town gas and from 40 b.h.p. to 45 b.h.p. on suction gas. The engine carries a single flywheel, 84 in. diameter by 9 in. wide on face, and a driving pulley 45 in. diameter by 15 in. wide, an outer bearing supporting the end of the crankshaft. The governor controls the gas supply alone, so that the strength of the mixture is varied while the compression remains practically constant at all loads. The air and gas valves are concentric. This system is said to have been found very satisfactory for electric lighting work as a very close governing is obtainable. A low tension magneto is used for ignition, the timing of the spark being effected by a small quadrant. The main bearings are of the four

EXHIBITS AT THE ROYAL SHOW AT DERBY.

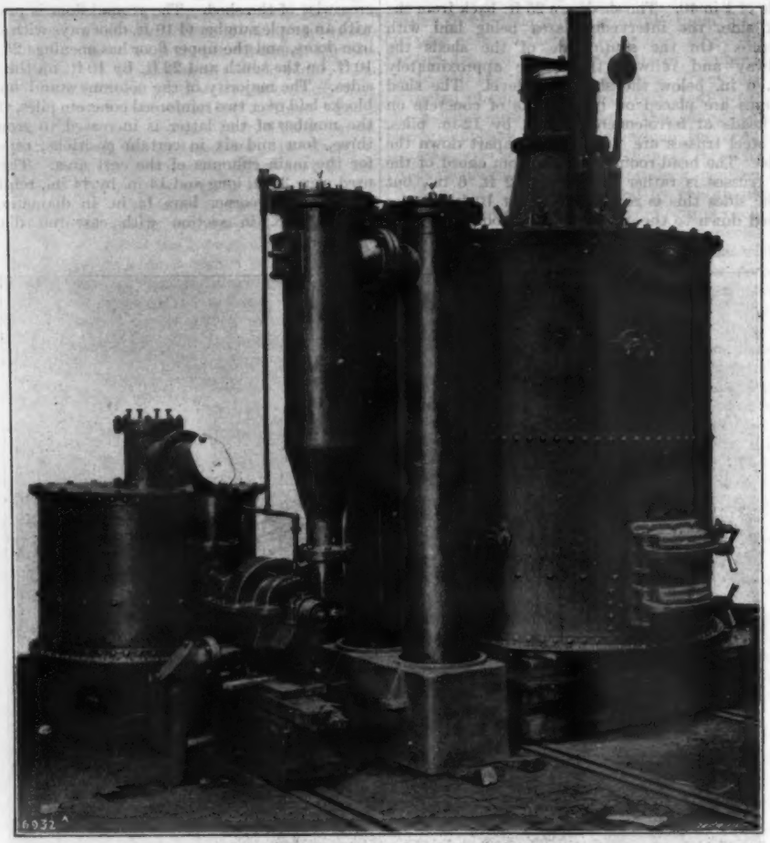


FIG. 1. SUCTION GAS PRODUCER FOR WOOD REFUSE; MESSRS. DAVEY, PAXMAN AND CO., LIMITED, COLCHESTER.

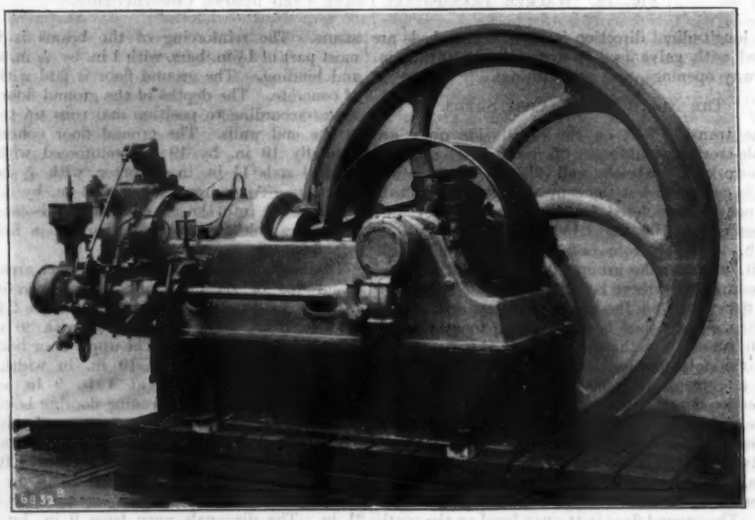


FIG. 2. 50-HORSE-POWER GAS ENGINE; MESSRS. DAVEY, PAXMAN AND CO., LIMITED, COLCHESTER.

50-HORSE-POWER GAS ENGINE AT THE ROYAL SHOW AT DERBY.

CONSTRUCTED BY MESSRS. DAVEY, PAXMAN AND CO., LIMITED, ENGINEERS, COLCHESTER.

Fig. 3.

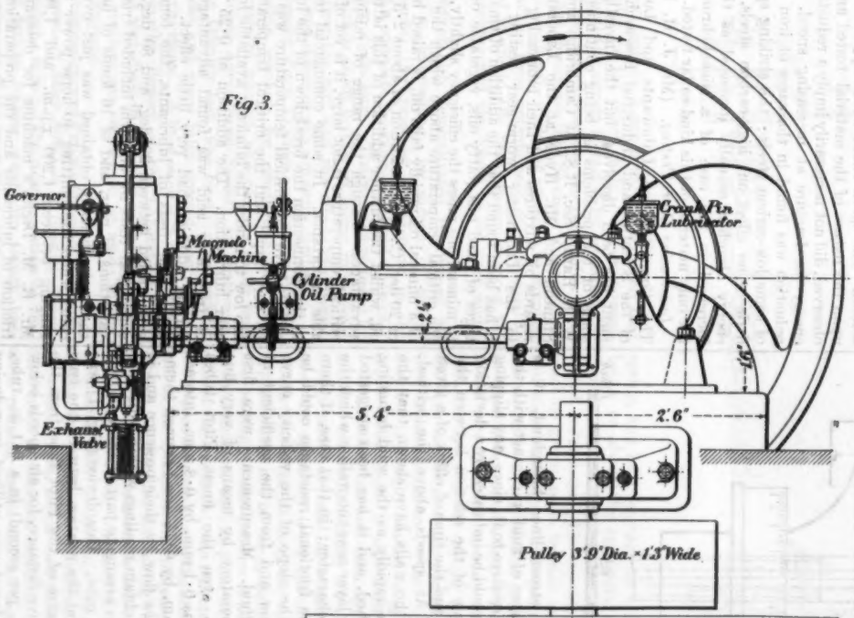


Fig. 4.

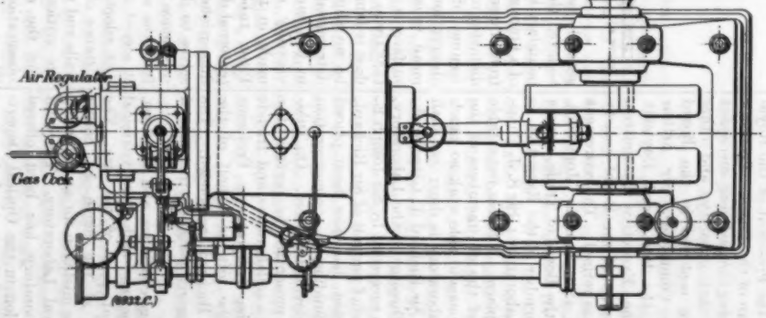


Fig. 5.

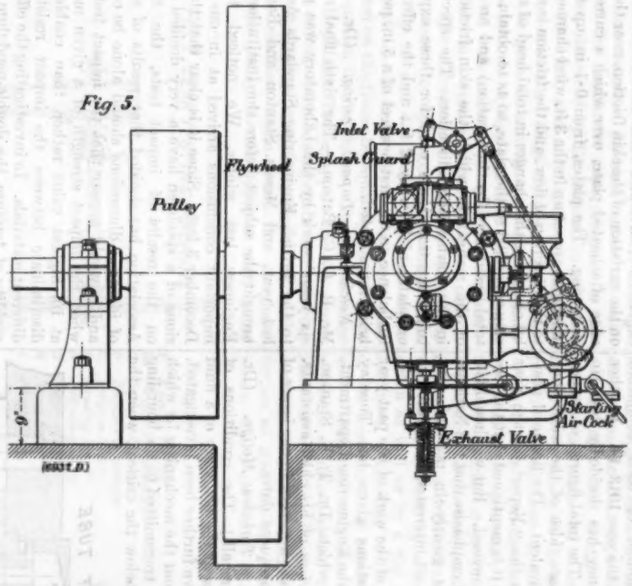
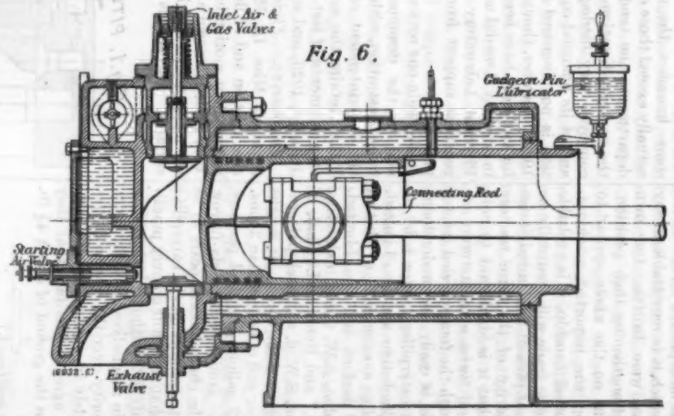


Fig. 6.



part type, 11 in. long, are fitted with chain lubrication and oil gauges. The piston is lubricated in the usual way by means of a pump driven from the side-shaft, and the other details of the engine follow generally along the lines of established practice.

We referred above to a 2-b.h.p. suction gas producer, exhibited by the National Gas Engine Company, Limited. This uses charcoal as fuel, and is mounted, together with its small horizontal gas engine, on a wooden truck, so that it constitutes a complete portable power plant. The whole set has the excellent workmanship characteristic of the makers, and is an attractive little plant—for those who have charcoal available. The same firm also exhibit a producer of 27 h.p. which follows along standard lines. Other suction gas producers are shown by Messrs. Crossley Brothers, Openshaw, Manchester, who show two plants of 37 b.h.p. and 7 b.h.p. respectively. These are fitted with the firm's open stepped hearths, which enable the fire to be poked as easily as the operation can be performed with a domestic fire grate. Messrs. Tangye's, Limited, Birmingham, Ruston and Hornsby, Limited, Lincoln, Fielding and Platt, Limited, Gloucester, and Peter Brotherhood, Limited, Peterborough, all show producers, which, however, do not appear to call for comment. Messrs. Producer Gas Plants, of 166, Piccadilly, London, W. 1, have a 3-ton lorry on view on the stand of the New Kilburn Colliery Company, Limited, of Smalley, near Derby, which is fitted with the Parker suction gas producer plant. A producer, gas cooler, &c., are exhibited separately so that visitors may see all the details of the very simple equipment. It is stated that with this suction gas producer the fuel consumption on a give-and-take country journey works out to less than 2¼ lb. of coke per mile, which is only about a quarter to a fifth of that used on a steam lorry. We illustrated and described the Parker suction-gas lorry very fully in our issue of

June 17, page 739, so that we need not deal with it further at the present time.

Agricultural tractors are represented at Derby in great variety, as might be expected. We counted 23 different makes, of which it is regrettable to say that less than one-third were British. Our own makers, however, are strengthening their position, and as their productions on the whole appear to be an improvement on the imported machines, particularly as regards workmanship, it is probable that the greater part of the trade will eventually be gained by this country. At present the United States supplies the great majority of the farm tractors used in Great Britain, but it is significant to note that French, Italian and Swiss manufacturers are now competing. Although the four-wheeled tractor with rear driving wheels is easily the predominant type, the chain-track or caterpillar tractor is by no means dead. Messrs. Blackstone and Co., Limited, of Stamford, are showing a caterpillar of British design, Messrs. H. G. Burford and Co., Limited, 16, Regent-street, London, S.W. 1 are exhibiting the American "Cletrac," and Renault, Limited, of West Brompton, London, S.W. 6, a French pattern. The latter is far the largest of the three. It weighs 3½ tons and has a drawbar pull of no less than 3 tons. It is said to consume 2 gallons of petrol per acre when ploughing average ground with a six-furrow plough. The wear of the chain links appears to be the principal objection to tractors on the caterpillar principle, but the fact that they will go over practically any ground whatever, without either consolidating it or sinking in themselves gives them one definite point of superiority over the wheeled type. The machines differ widely in weight, size and construction, but they all agree in the fact that they only exert a pressure on the ground of about 4½ lb. per square inch.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

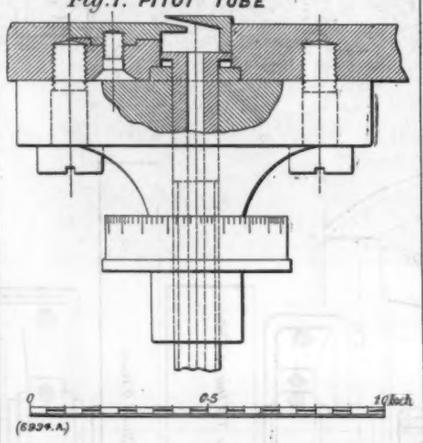
THE inspection of the National Physical Laboratory took place on Tuesday last, when a large number of visitors, invited to meet the General Board, were received by the President of the Royal Society, *ex-officio* chairman of the Board. Professor C. S. Sherrington had, during the past year, succeeded Sir J. J. Thomson in that capacity, and other important changes have occurred in the Board and in the Executive Committee. Sir Arthur Schuster has followed the late Lord Rayleigh as vice-chairman of the Executive Committee. Sir Alfred Kempe, Treasurer of the Royal Society and of the Laboratory, has retired. The retirement of Lord Southborough (Sir Francis Hopwood), Permanent Secretary of the Board of Trade, and as such another *ex-officio* member of the Executive, is also a great loss to the Laboratory; Sir S. J. Chapman has stepped in his place. Not less regrettable are the losses of some of the old members of the staff to whose conscientious and able work so much of the success of the Laboratory is due; we shall refer to these changes. Sir Richard T. Glazebrook, the organiser and first Director of the Laboratory, had in 1919 already been succeeded by Sir Joseph E. Petavel; a bronze bas-relief portrait of Sir Richard, made by a Brussels artist, has now been placed in the Administration Building in commemoration of his distinguished and devoted services. On Tuesday, Sir J. J. Thomson presented the portrait, the donation of Sir Richard's collaborators and friends within and without the Laboratory; Professor Sherrington accepted the gift on behalf of the Laboratory and Sir Richard responded. The simple, impressive ceremony preceded the general reception.

The growth of buildings continues, and additions, chiefly to the engineering and aerodynamical departments, crowd that part of the site. The Admiralty Laboratory, at the north-east corner of the grounds, might be mistaken for an extension of the National Physical Laboratory. The staff of the Admiralty Laboratory has been offered temporary accommodation in the Optical Department and other buildings of the senior Laboratory. Close co-operation of the two institutions is in accordance with the general resolution of the Scientific and Industrial Research Department to make the fullest use of the facilities for research of the Laboratory. The routine test work has continued to increase in some departments, and in some branches the number of tests completed actually exceed those of the year 1913–14. In other departments the tendency has decidedly been in the opposite direction. The total figures, of course, convey a very inadequate idea of the work done and of its financial equivalent. The financial position is not discussed in the "Report for the Year 1920," however, though it is mentioned that the fees for test work have been revised. But we should fail in our duty if we did not emphasise that the National Physical Laboratory is greatly in need of very generous support from all interested in research at present.

We begin our review of the work of the past year and of the demonstrations given last Tuesday in its illustration, with the Engineering Department, the superintendent of which, Dr. T. E. Stanton, F.R.S., retains the services of his chief assistants. Our comments of last year appeared in our issues of June 25, 1920, and subsequent dates.

Engineering. Fluid in Turbulent Motion. (Dr. Stanton, Miss D. Marshall.)—The conditions of skin friction and of flow at the boundary of a fluid in turbulent motion have further been investigated. Very little is known about the mechanism by which the resistance to flow is transmitted to the bounding surfaces. For speeds below the critical, when the

Fig. 1. PITOT TUBE



general motion is stream-line throughout, it is believed that the layer of fluid in contact with the boundary is at rest relative to it, since any slipping of a finite amount would be indicated by a deviation from Poiseuille's law of the relation between the diameter of a pipe and the time of efflux of a given volume of fluid. At speeds above the critical, observations near the walls have shown that the mean velocity falls rapidly as the solid bounding surface is approached, and it has been suggested that there is a thin layer near the wall in which the flow is laminar in character; in that case, if there be no slipping, the frictional resistance could be determined from the slope of the velocity curve in the surface layer and from the coefficient of viscosity of the fluid. Measurements were first made in the Laboratory by means of very fine Pitot tubes. But even the finest Pitot tubes (external dimensions 0·1 mm. by 0·8 mm., internal dimensions 0·05 mm. by 0·75 mm.) seemed themselves to disturb the flow by their presence and it was hence tried to obtain readings within 0·01 mm. from the wall by so arranging part of the wall that it served as Pitot tube. This device (Fig. 1) was first adopted to find the relation between the true distance of the centre of the Pitot tube from the walls and its effective distance, for air speeds below the critical (50 ft. per second) in a 0·1 in. tube, and the relation found was utilised in reducing observations with turbulent flow in larger pipes. The general conclusion drawn from the series of experiments is that in turbulent motion there exists at the boundary a layer of fluid of finite thickness which is in laminar motion and has zero velocity at the boundary.

Heat Emission from thin Plates exposed to Air Currents.—In connection with these experiments experiments have also been made in a wind channel on the variation of the skin friction, near the leading edge of a heated plate, over which a current of air is flowing. The plates, from 0·1 in. up to 18 in. in length, are set up in the 3 ft. wind channel parallel to the direction of flow, and the friction is measured by observing the changes in total head of the air in planes parallel to the plate, so as to obtain both the total resistance (by integration) and an estimate of the manner in which the skin friction varies in the down-stream direction. The special Pitot tubes mentioned are used for these experiments on plates of 3 ft. by 2 ft., and the effect of the turbulence on the first few feet of a 5 in. pipe is also being investigated.

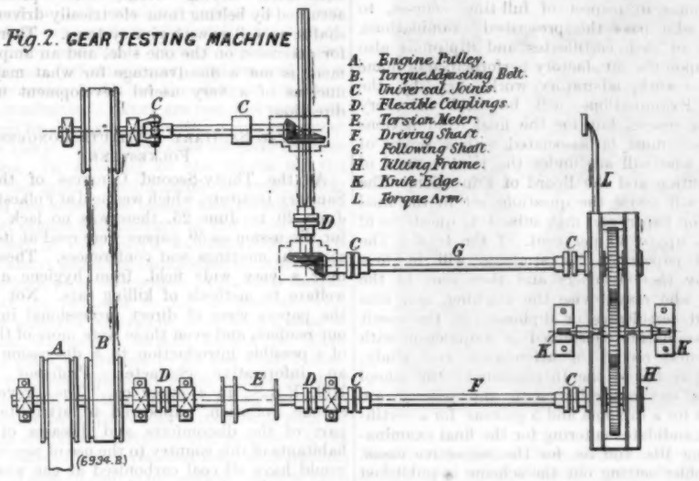
Notched-Bar Impact Testing. (Dr. Stanton, Mr. R. G. C. Batson.)—The sixth final report on six years' work by the Laboratory was presented to the British Engineering Standards Association last year, and Messrs. Stanton and Batson also brought the subject before the Institution of Civil Engineers last winter. We noticed the very important conclusions arrived at in our issue of December 3 last. Since it is clear that the dimensions of a specimen have a very decided influence on the results of impact tests, the Standards Association has decided that results of specimens of identical dimensions should alone be compared, and it would appear that the impact test tells us when the impact strength of a given material is at its highest value rather than enables us to discriminate between the impact resistances of different materials. In investigating the effect of the rapidity of fracture, the double-pendulum machine was used, and the striking velocity was thereby raised from about 20 ft. per second to 43 ft. per second. The speed effect would appear to depend upon the nature of the material tested and, when observed, did not necessarily imply a reduction of the energy for fracture at increasing speed. Such a reduction was found in the cases of iron and also of some low-carbon steels; the striking speed had little or no effect on high-carbon steels, and the energy absorbed actually increased as the speed increased in the case of a nickel-chrome steel, the only material of this kind so far tested.

Lubricating Gear Testing. (Mr. J. H. Hyde.)—The Committee on Lubricants and Lubrication of the Scientific and Industrial Research Department has been dissolved, but the investigation of some of the problems is being continued by Mr. W. B. Hardy, Sec. R.S., at Cambridge and by Dr. Stanton and Mr. Hyde at the Laboratory. As regards oil mixtures and their lubricating efficiency in the Lanchester worm-gear testing machine, it has been found that the addition of small percentages of fixed oils (fatty oils, vegetable or animal) to mineral oils raises the efficiency slightly, and that the critical temperature above which the efficiency of a mineral oil rapidly falls off, is raised by 10 deg. or 20 deg. C., by the addition of about 2·5 per cent. oil, whilst the further addition of this latter has no advantages. Though the range of raising of the critical temperature is not large, it is yet of considerable importance. In some commercial tests made in this connection the breakdown of the lubricating value above the critical temperature was found to be very rapid and the critical temperature itself too low to render the lubricant available for turbine gear lubrication. The addition of 0·25 per cent. of free fatty acid was found advantageous, but further addition had very little effect. In these worm gear tests of lubricants, the temperatures were varied between 20 deg. and 80 deg. C. The worm gear tests for one firm included trials of four variations of gear, and of 16 kinds of lubricants; the best efficiency obtained was just over 97 per cent. when transmitting 40 horse-power at speeds ranging between 1,200 r.p.m. and 1,800 r.p.m. Mr. R. M. Deeley's machine for determining the friction of lubricants and the preparation of steel (friction) plate for them were demonstrated last Tuesday by Mr. Hyde, who is further studying this valuable, but exceedingly sensitive machine.*

* See ENGINEERING, June 10 last, page 708.

Spur, Bevel and Chain Gears. (Mr. Hyde, Mr. H. V. Pollard.)—Since in power transmissions by means of spur and chain gears efficiencies of the order of 97 per cent. are frequently reached, very accurate measurements of the torque ratio or torque difference are required in such cases. A small machine of the Lanchester type designed for this purpose was described by Dr. Stanton in our issue of March 12, 1920, and a full-scale machine has since been constructed (Figs. 2 to 4). The frame carrying the gears is entirely supported on knife edges, and both the driving and the following shafts are provided with universal joints so that the frame can oscillate in a vertical plane about its neutral position. The intermediate wheel in the tilting frame is needed for spur gearing (not for chain gearing, Figs. 3 and 4), because the two shafts should rotate in the same direction in order that the reaction on the frame be equal to the difference of the torques on the two shafts. The torsion meter is of the Hopkinson-Thring type. For the return of the power from the following shaft to the driving shaft a belt-slipping device is employed, as in the Lanchester machine worm gear, the peripheral speed of the pulley on the follower shaft being

Fig. 2. GEAR TESTING MACHINE



from 3 per cent. to 5 per cent. greater than that of the pulley on the other shaft; the power transmitted round the circuit is varied by adjusting the tension of the belt connecting the two shafts. The torque in the circuit can thus be made to correspond to as much as 75 h.p., while the power to be supplied to the machine from outside need only be equal to the loss of power in the bearings and gears of the testing machine and the losses in the gear under test.

Dr. Stanton also demonstrated the use of his machine for determining, by means of torque measurements, the pressure distribution in the oil film of a complete bushing all round a pin of 1 in. diameter, 2½ in. long. The pin is surrounded by a ring, which is about 0·0005 in. larger in internal diameter than the pin, and the effects of different clearances and different oils are being studied.

Dynamometer, Farm Tractors and Tractor Ploughs.—Mr. Hyde's machine for conducting the competitive trials of tractors and ploughs to be held by the Royal Agricultural Society at Aisthorpe, Lincoln, in October last, was briefly described by us last year and more fully noticed later in our report on the Show. A brief summary of the trials is given in the Report of the Laboratory. We should add that draw-bar tests on tram cars fitted with ball bearings are shortly to be made in the North of England.

Rapid Determination of Fatigue Ranges of Materials under Reversals of Shear Stress or of Bending Stress. (Mr. H. Gough, B.Sc.)—The demonstration of the method of fatigue testing which Mr. Gough has developed was one of the most interesting novelties of the day. In 1914, Mr. C. E. Stromeyer had presented to the Laboratory a machine for determining fatigue ranges under reversal of shear stress. Forced torsional vibrations are given to the specimen under test by means of a rocking arm and flywheel of adjustable mass, the specimen acting as an elastic constraint between the rocking arm and the flywheel. The usual method of finding the limiting range of stress by endurance tests required six specimens and six days with the machine running continuously. Mr. Gough determines with the machine the range on a single specimen, by two independent means at the same time, all within a period ranging from 5 minutes to 15 minutes. A simple form of extensometer and a thermocouple are fitted to the specimen; the range of shear stress is raised by regular steps, and at each range of stress the strain and the temperature of the specimen are measured. At a definite value of the stress a yield will occur, marked by a sudden increase in the strain as well as by a rise of temperature in the specimen. According to Dr. J. H. Smith (Journal of the Iron and Steel Institute, 1910, No. 2), who used a similar extensometer while experimenting on reversals of direct stress, these yield ranges are identical with the fatigue ranges. In order to conduct tests under combined stress Mr. Gough further so fixes the specimen between two curved levers, which are forced apart above by a helical spring, and held together by a fulcrum bar, either below or above the specimen, that the specimen is under tension or compression while subject to the forced vibrations. The speed regulation of the machine giving some trouble with continuous day and night running, a small centrifugal water pump connected to a long vertical glass tube was adopted as speed indicator. A branch from the pump leads to a U-pipe filled with mercury whose height changes with the speed of the driving electric motor. Two contacts in the mercury operate a relay shunting the motor armature; the "hunting" of the mercury is thereby limited to ⅛ in., and the speed (up to 1,000 r.p.m.) is kept constant within 3 r.p.m.

The method has also been applied to the Wöhler machine of the Laboratory for determining fatigue ranges under reversal of bending stress. In this case the specimen is of the form of a rotating cantilever driven at constant speed. The load is applied at the end of the specimen by a stirrup and ball bearing; a small mirror is also fixed to the end of the specimen, with its plane at right angles to the axis of the specimen; the reflected image of a lamp is focussed on a scale, and the change of slope of the end of the specimen with increase of stress is determined. A machine for taking similar observations on rectangular specimens is under construction.

Bearing Friction, Grinding Attachment. (Mr. C. Jakeman.)—Mr. Jakeman's machine for determining the coefficient of friction of shaft bearings of various types, which we illustrated last year, has been much in demand, especially for tests at maximum running loads and at high speeds ranging up to 1,500 r.p.m. At first it looked as if both the bearings and the balls of makers of repute would not fail at all, unless dangerously loaded, and it is only recently that a few failures have actually been observed. Failing rollers seem to develop cracks at the centre. Properly-mounted bearings, properly protected from dirt and moisture, will at any rate stand more than is sometimes regarded safe for them. A curious observation made is that both ball and roller bearings, run for a few minutes at the nominal maximum load, had their coefficients of friction reduced when subsequently run at lower loads, reductions of more than 10 per cent. being observed; the coefficient of friction was in some cases reduced to 0·0004. Whether this is generally so cannot be said at present. White metal bearings have also been tested with different lubricants. A British firm constructing grinding heads for small internal grinding wished to know whether their spindle speed of 45,000 r.p.m. was really attained. The drive is by means of a stretched rubber band. At speeds of 20,000 revolutions and 30,000 revolutions the slip observed was negative, *i.e.*, the grinding spindle was running faster then the pully ratio indicated, and even at the full 45,000 r.p.m. there was a slip of ⅛ per cent. The makers have since raised the speed to 100,000 r.p.m., and this speed is to be tested.

Heat Insulation of Steam Pipes.—These experiments, which had had to be suspended, are now

Fig 3. TILTING FRAME TESTING SPUR & HELICAL GEARS.

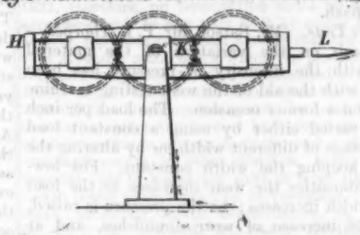
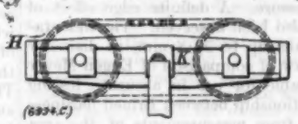


Fig 4. TESTING ROLLER OR ROCKER CHAINS.



being resumed; the 4-in. pipe is first to be tested bare for radiation losses, the steam temperature being raised to 900 deg. F. by an internal electric coil which will absorb 17 kw.

Building Materials. Reinforced Concrete.—The machine for testing reinforced concrete floors and columns, for which Sir John Cowan provided funds before the war, is now being erected. The machine was designed by Messrs. Redpath, Brown & Co., of Edinburgh, and by Mr. Hyde, and was constructed by that firm. With the aid of weighbeams, levers and knife edges measurements will be made on masses of 50 tons, slabs 6 ft. wide by 14 ft. long and columns 14 ft. high. This work is in the charge of Dr. Stanton and Mr. Batson. The effect of vibration during the moulding of concrete blocks has been investigated by Mr. Batson for the Ministry of Transport. Two sets of tests have been made, each on a series of 12 blocks, six of a set being made in the usual way, while the other six were vibrated for about 30 seconds by a Boyer pneumatic hammer applied to the outside of the moulds. Tested in compression 28 days afterwards the first set showed that the shaking lowered the strength by about 9 per cent.; in the second set more water was added to the concrete, which then proved more uniform in the tests, but also of reduced strength, though the shaking made little difference. Mr. Jakeman has also experimented on the strength of the rammed earth walls, used for ordinary buildings of one storey and sometimes two storeys in France and Belgium, and known as "*pisé de terre.*" Such walls will bear a load of 1 ton per square foot before collapsing, but they should be built in the dry. Some other waste materials seem to be more promising, when combined with lime or cement, than these earth walls.

Road Board. (Mr. Batson.)—The road-testing machine was once more seen in operation last Tuesday. A new asphalt carpet had been laid down by the Oil Trust, Limited, and the heavy

spider with its eight radial arms, each carrying a wheel at its end, was running at speeds ranging from 1 mile up to 9 miles per hour. A full-size mixing plant with control instrument for road-making has been supplied by the Ransome Machinery Company at Tipton, and this work will be resumed.

Motion of Projectiles in Flight. (Mr. Batson, Mr. H. J. Tapsell.)—Experiments on photographing the pressure waves which travel with a flying rifle bullet having been successful, a range has been constructed on the instigation of the Director of Naval Ordnance for investigating the stability of a 1-in. projectile. This range is a tunnel, 6 ft. square (with rounded corners at the ceiling), 50 yards long, provided with ferro-concrete walls, 4 in. thick; the excavated earth has been heaped on the top of the tunnel. At the one end of the tunnel, behind a partition, is the Hotchkiss tube for discharging the projectile, at the other end is the sand butt; projecting from the left side of the tunnel are eight pairs of steel levers to hold the brass frames of the cards for the first series of experiments. Later on the wires and condensers wanted for the photographic tests will be added; these devices were, in the previous experiments, so arranged that the bullet closed a spark gap for producing the illuminating flash.

Hardness Tests. (Mr. Batson, Mr. P. L. Thorpe.)—The research on the variation of the material abraded with the intensity of pressure has been continued with the aid of the wear-testing machine described on a former occasion. The load per inch has been varied either by using a constant load and wear rings of different width, or by altering the load and keeping the width constant. For low-pressure intensities the wear increases as the load per unit width increases; as the pressure is raised, the rate of increase of wear diminishes, and at high pressure the wear may actually be smaller than at lower pressure. A definite edge effect of the wearing had also been observed. The indentation tests with balls up to 50·8 mm. in diameter showed that the law of comparison of Eugen Meyer is sufficiently reliable for use in accurate testing practice; the relationship between Brinell hardness numbers deduced from measurements of the area and of the depth of the indentation is still under investigation. As regards scratch hardness tests a machine is being calibrated for studying the relation between the load on the diamond and the volume of material it will remove in a test.

With respect to mechanical properties of insulating materials, investigated for the British Electrical and Allied Industries Research Association, the Report unfortunately does not say more than that tooling, brittleness and crushing tests have been made and the moduli of elasticity have been determined.

Gas Cylinders. (Mr. A. Bailey, M.Sc.)—Solid drawn cylinders of a medium carbon steel, 6 in. external diameter, ¼-in. wall thickness, containing about 100 cub. ft. of gas at 120 atmospheres and weighing 70 lbs. each, have been tested. The complete cylinders are submitted to internal water pressure, drop tests and rough handling, and specimens of the steels are examined in the usual way; 11 sets of tests were made on cylinders supplied by two firms; the cylinders had either undergone a heat treatment by two methods or had not had any heat treatment. These latter cylinders did not pass; all the heat-treated cylinders gave a very substantial margin of safety so that it was considered that the weight of such cylinders might safely be reduced to 70 per cent. of the actual figure.

Detonation in Internal Combustion Engines. (Mr. R. W. Fenning, B.Sc.)—We noted the apparatus constructed for this research by Mr. Fenning, on lines suggested by Sir Dugald Clerk last year. A preliminary report, presented to the Engine Sub-Committee of the Aeronautical Research Committee acknowledged the need of further improvements of the apparatus. The effect of stirring the gases—so far mostly hydrogen and oxygen in various proportions—and apparatus for working with liquid fuels are now being studied.

Fire Protection on Aircraft.—The experiments by Mr. G. A. Hankins on the prevention of fire by magneto-sparking, which we mentioned last year, have led to the drawing up of specifications by the Laboratory, in conjunction with the Royal Aircraft Establishment at Farnborough. The further tests by Mr. Hankins concern sparking by snapping wires, glowing wood, etc., and the danger arising when spilt oil comes in contact with hot plates. The fire risks from these sources are not great in general, but little-volatile oils are more dangerous than highly-volatile vapours.

NOTES.

National Certificates and Diplomas of the Institution of Mechanical Engineers.

Under the title of the "Arrangements and Conditions for the Award of the National Certificates and Diplomas of the Institution of Mechanical Engineers in Conjunction with the Board of Education," there has recently been issued a pamphlet by the Board of Education setting out the regulations under which these certificates and diplomas will be granted. The Institution in question, in conjunction with the Board, are prepared to approve suitable educational courses submitted by technical schools and colleges and to grant certificates in respect of part-time courses, and diplomas in respect of full-time courses, to students who pass the prescribed examinations. The issue of such certificates and diplomas also depends upon the satisfactory performance of home work, class-work, laboratory work, &c., by the student. Examinations will be held in every year, of a course, but for the final examinations the teachers must be associated with a Board of Assessors who will act under the joint control of the Institution and the Board of Education. The assessors will revise the questions set in the final examination paper, and may substitute questions of their own up to 40 per cent. of the total. The completed papers of the students will be first marked by their teachers and then sent to the assessors, who may revise the marking, and who will award certificates or diplomas on the result of the examination considered in conjunction with the students' record of attendance and study. The fees payable to the Institution by the school authorities in connection with the scheme are 10 guineas for a diploma and 5 guineas for a certificate, the candidates entering for the final examination paying 10*s.* and 5*s.* for the respective cases. The pamphlet setting out the scheme is published by H.M. Stationery Office at the price of 1*d.*, and the correspondence in connection with any matter arising out of the scheme should be addressed to the Secretary of the Institution of Mechanical Engineers, Storey's Gate, London, S.W. 1.

Intermediate-Scale Chemical Laboratory at South Kensington.

The Whiffen Laboratory, which was opened in the Imperial College of Science and Technology at South Kensington on Friday last, is to enable the third year's student to prepare himself for submitting tons of materials in plant, constructed by engineers, to processes which he has studied and worked out by experimenting with grammes or kilogrammes in small apparatus largely made by glass. Use is also to be made of the new laboratory for the preparation of considerable quantities of organic substances which are not generally obtainable and which will thus be rendered available to original workers in other laboratories of the country. In other words, organic reactions are to be studied on a semi-technical scale and intermediate organic products are to be made in the new laboratory; Mr. A. J. Balfour, M.P., was probably to be understood in this sense when, in declaring the laboratory formally open, he spoke of this new, not inhazardous experiment as having no parallel in the world. Technological laboratories equipped with working machinery are already connected with several universities of this country. Organic chemistry was not mentioned at all by the speakers. But the Whiffen Laboratory is an addition to the organic chemistry department at South Kensington. It will be in charge of Dr. J. C. Thorpe, F.R.S., professor of organic chemistry, assisted by Dr. Ingold, and will not in any way compete with the extension of another part of the Imperial College of Science and Technology, which has been mentioned in our columns, and which is formally to be opened this autumn. In the semi-large scale laboratory, the student will be able to familiarise himself with the proper materials in which to carry out his operations, with their limits of resistance, the yield and waste of a process, the purity of the product attainable and with promising lines of development. The benefit will, in the first instance, be to the student, in the second instance to the discoverer and the manufacturer, and finally to the nation and to the college, the utility of which will more widely be appreciated. The generous and enlightened liberality of Mr. G. W. Whiffen—an old chemical student of the college, who was present—was duly acknowledged by the Marquess of Crewe, who presided as Chairman of the Governing Body of the college, as well as by Mr. Balfour. Lord Crewe made one characteristic remark; he spoke of these days in which economy is on the lips of everybody and in the hearts of some. The new laboratory forms an annexe to the third floor of the college building and looks like a rather crowded portion of some chemical factory. It is well equipped with sulphonation and nitration vats, stills, centrifuges, autoclaves, drying ovens, filter presses, &c., actuated by belting from electrically-driven counter shafts, as well as with pipe systems. There is room for extension on the one side, and an ample equipment is not a disadvantage for what may be the nucleus of a very useful development in a new direction.

Royal Sanitary Institute Congress at Folkestone.

At the Thirty-Second Congress of the Royal Sanitary Institute, which was held at Folkestone from June 20 to June 25, there was no lack of topics for discussion as 59 papers were read at its various sectional meetings and conferences. These ranged over a very wide field, from hygiene and child welfare to methods of killing rats. Not many of the papers were of direct professional interest to our readers, and even these were more of the nature of a possible introduction to a discussion than of an informative character. Professor Leonard Hill, F.R.S., in a paper on "The Prevention of Smoke Pollution," appeared to attribute a large part of the discomforts and diseases of the inhabitants of this country to the use of raw coal. He would have all coal carbonised at gas works, coke and gas alone being used for industrial and household purposes, "a change which would bring about more advantages than we have space to set down." In comparison with the efficiency of our power stations, he states that the luminous efficiency of a glow-worm is 100 per cent., but this information, even if accurate, is of no practical use until we can find glow-worms of several thousand horse-power capacity. A paper on "Smoke Abatement," by Dr. J. S. Owens, gives interesting figures on the deposit from the atmosphere in various localities. The mean monthly deposit for the year ending March 31, 1920, varied from 39·30 tons per square mile in Southwark Park, London, to 7·02 tons in Malvern. In St. Helens the monthly deposit per square mile was 35·40 tons, and in Queen's Park, Glasgow, it was 31·10 tons. The annual deposit in London has decreased continuously and fairly regularly from 1916 to the present date. This deposit consists approximately of tarry matter 0·7 per cent., carbonaceous matter 15·60 per cent., insoluble mineral matter, ash, &c., 36·20 per cent., combustible soluble matter 13·40 per cent., and mineral soluble matter 34·10 per cent. Interesting also are the data on the hourly rate of smoke production, and the conclusive evidence that the domestic fires are far more responsible than factories for the pollution of the atmosphere. In a paper on "The Utilisation of Sewage Sludge," by Mr. John D. Watson, M.Inst.C.E., it is shown that sewage sludge is very much inferior to farmyard manure as a fertiliser, and hints are given as to treatment which will make it more valuable to the farmer. The production of power gas from septic sludge is in successful operation in Australia. Air is blown through the fermenting sewage, and a gas obtained containing 60 per cent. of CH_4 and 8 per cent. of H, the incombustible portion being 16·9 per cent. nitrogen, 14 per cent. CO_2 and 1·1 per cent. of

oxygen. One brake horse-power is said to be obtained per 20 cub. ft. of this gas, but there is no information as to the quantity of gas generated per ton of sewage. Another use for sewage sludge is as a fuel. Birmingham sludge is said to have a calorific value of 2,200 B.Th.U. per pound, or about one-fifth of that of Midland slack. Air-dried sludge will evaporate 1 lb. of water per pound, and samples of heat-dried sludge have been found to have a calorific value between 4,000 B.Th.U. and 5,000 B.Th.U. per pound.

X-RAY AND RADIUM PROTECTION.

The preliminary report issued last week by the X-Ray and Radium Protection Committee is admittedly tentative in some of its recommendations. As a carefully thought-out statement by leading representatives of scientific bodies, both medical and physical, however, the recommendations as to equipment, ventilation and working conditions deserve attention, particularly because the committee is responding to urgent demands for guidance from institutions and individuals. There is no cause for alarm. The report expressly states that the danger of over-exposure to X-rays and radium can be avoided by the provision of efficient protection and suitable working conditions. When reading of X-ray martyrs the public are apt to think that the sometimes vaguely-implied suggestions of heroic, yet unnecessary, recklessness, are a little ungenerous, and that the dangers are more real than is admitted. They are real, but much can be achieved by due care, and without due care most things are risky. The report does not refer to these impressions. In speaking of the effects on the operator the report distinguishes between visible injuries of the superficial tissues and derangements of internal organs and changes in the blood—often unrecognised in their early manifestations; it is the latter about which the radiologists and therapists are, we believe, most concerned. Apparatus should, in general, be enclosed so far as possible with protective material equivalent to at least 2 mm. of lead. The fluorescent screens should be fitted with lead glass equivalent to no less than 1 mm. of lead; practical difficulties so far militate against higher demands in this case as in some others. There should be a travelling screen of 2 mm. of lead or its equivalent between operator and X-ray box; for lead-rubber gloves, best lined with leather, at least 0·5 mm. of lead is demanded. Screen work is to be as expeditious as possible. Work in small cubicles is not recommended; where in existence the cubicle should be ventilated by an electric fan, all control being from outside. For deep therapy at more than 100,000 volts, boxes with 3 mm. of lead, separate enclosures for the operator, and large, lofty, well-ventilated and lighted rooms are required; those conditions will be preferable also for industrial work at lower potentials. Work below ground is to be deprecated, and good ventilation is insisted upon since the corona discharges generate ozone and nitrous vapours. Dark rooms should be accessible to sunlight and air when not in use. The precautions as to electric equipment rather seem to suggest frequent minor accidents: concrete floors should be covered with wood, cork or rubber, bare wire conductors be replaced by stout metal tubes or thickly insulated wires, slack wires be avoided, all metal parts be well earthed, unemployed leads to high-tension generators not be permitted, and double pole switches (not single) be used. There are some special rules as to the handling of radium and its emanation. The safety of operators is very rightly emphasised. They are not to be employed for more than seven working hours, and to have their Sundays and two half-days off and an annual holiday of a month or two separate fortnights. It is finally pointed out that the National Physical Laboratory is prepared to test and to arrange for periodic inspection of installations.

THE LATE SIR HERBERT BABINGTON ROWELL, K.B.E.

WE regret to have to announce the sudden death, which occurred at Redesmouth House, North-Tyne, on Thursday, June 23, of Sir Herbert Babington Rowell, K.B.E., chairman and managing director of Messrs. R. and W. Hawthorn, Leslie and Co., Limited, shipbuilders and engineers, Hebburn and Newcastle-on-Tyne.

Sir Herbert, whose portrait we reproduce on the present page, was the son of the late Mr. Robert Rowell, and was born in 1860. He received his education at Mill Hill School, later in Switzerland, and also at Glasgow University, where he studied naval architecture under Professors Elgar and Jenkins. He served his apprenticeship with Messrs. Wigham Richardson and Co., and afterwards entered the service of Sir W. G. Armstrong, Whitworth and Co., Limited, where he worked under the late Sir William White and Sir Philip Watts, at Low Walker, Elswick and Pozzuoli. At this latter yard he superintended the construction of Italian coast defence ships. He left Italy in 1890, and shortly afterwards was appointed manager of the Hebburn Shipyard of Messrs. R. and W. Hawthorn, Leslie and Co., Limited. In 1896 he was given a seat on the directorate of the firm, and in 1916 succeeded the late Sir Benjamin Browne as managing director. Under Sir Herbert's management Messrs.

Hawthorn, Leslie and Co. specialised in the construction of destroyers, and about twenty-one years ago they built the Viper, which was propelled by Parsons compound steam turbines, and attained at the trials, as indicated in one of our former issues (ENGINEERING, vol. lxix, pages 219 and 625), a mean speed of 33·96 knots on a 3-hours run. The illustration we gave at the time showed the Viper steaming at a speed of 35·5 knots. Besides a number of destroyers for the British Navy, Sir Herbert's work at Messrs Hawthorn, Leslie has included a number of large merchant ships, ore carriers, troop ships, river steamers and other vessels, for various British and foreign concerns.

Sir Herbert was the first lecturer in Naval Architecture at Armstrong College, Newcastle. He was a member of the Institution of Naval Architects since 1888, and a member of council of that Institution since 1914. He frequently took part in the discussions and read two papers, entitled "The Russian Volunteer Fleet," in 1905, and "Oiltight Work in Ships of Light Construction," in 1906. He was a member of the Institution of Civil Engineers since February, 1910. Sir Herbert was also president in 1912 to 1914 of the Shipbuilding Employers Federation; president from 1915 to 1917 of the North-East Coast Institution of Engineers and Shipbuilders; vice-president of the Federation of British Industries; a member of the Northumberland Territorial Force Association; a member of Lloyd's Technical Committee; and of the Privy Council Committee on Scientific and Industrial Research. Sir Herbert was also a Justice of the Peace for the County of Durham. During the war he was a member of the Merchant Shipping Advisory Committee. He also served on the Council of the Industrial Welfare Society, on the Admiralty Shipbuilding Council, and on other bodies, to all of which he devoted a very large share of his energies.

Sir Herbert was knighted in 1918.

DISCHARGE THROUGH VENTURI TUBES—ERRATUM.—In the letter to the Editor which appeared in our issue of June 17 (page 743) the word "suitable" two lines above the illustration should have been "subtle," and the words under Mr. Hodgson's signature "Assoc. F. Cie. Soc." should have been "Assoc.F.Aë.Soc."

INDUSTRIAL NOTES.

A CALL issued at the end of last week by the Miners' Executive, addressed to other trade unions, asking these to declare a sympathetic strike, was left unheeded. Last Saturday the Prime Minister wrote to Mr. Evan Williams, Mining Association, saying he had received a request from the Miners' Federation to convene a joint meeting with a view to negotiating a satisfactory wages agreement. This joint meeting was held last Monday evening, following a meeting between the Mining Association and the Miners' Federation held earlier in the day. Mr. E. Williams, speaking on behalf of the owners, felt compelled to state that without Government assistance at the present moment it would be exceedingly difficult, if not impossible, to get a start in many districts, and equally difficult and impossible for the owners to apply in actual practice the arrangement they had arrived at with the Miners' Federation. They associated with the Miners' Federation on this occasion in asking Government to reconsider the question, and to maintain the grant of 10,000,000*l*. Mr. Williams confirmed the fact that the owners did not ask for a single penny of any Government assistance that might be forthcoming. The arrangement the owners proposed was that from now to the end of September Government assistance should be forthcoming as originally promised, and that the agreement arrived at should run for a definite period of twelve months from the latter date and be subject thereafter to three months' notice; until the end of December, 1922, therefore, no termination could be put to the agreement, nor to any part of it by either side. The owners, for their part, had agreed that the guarantee they give of a point below which the percentage of the standard would not fall shall be extended to December, 1922. Mr. F. Hodges also asked that the offer of the 10,000,000*l*. Government grant be maintained. If it were not, after the owners had given up the whole of their profits in certain districts, and a part of their standard profits in other districts, there would be possible cuts in wages per shift of from 10*s*. 10½*d*. in South Wales down to 2*s*. 2½*d*. in Yorkshire. In Lancashire, including North Staffordshire, it would be 5*s*. 5*d*.; in Scotland, 5*s*. 8½*d*.; Northumberland, 7*s*. 6½*d*.; Durham, 3*s*. 9½*d*.; North Wales, 6*s*. 10*d*.; South Staffordshire and Shropshire, 7*s*.; Cumberland, 9*s*.; Bristol, 5*s*. 4*d*.; Forest of Dean, 7*s*.; Somerset, 3*s*. 10½*d*. If the Government could not renew the offer of the grant there could, in the nature of things, be no general resumption of work Other meetings were held, and as a result an agreement has been entered into between the owners and the miners, and this is being recommended by the leaders to the workers. It has been decided also to allow the grant of £10,000,000 by Government.

Mr. Bridgeman, Secretary of Mines, speaking in Parliament last Monday, in reply to a question as to whether he could state approximately the quantity of coal that had been imported into this country from the United States, France, Belgium and Germany since the coal dispute had existed, said the quantities of coal recorded as imported from the United States, France and Belgium since April 1 were approximately: United States of America, 335,000 tons; France, 430,000 tons; Belgium, 495,000 tons. Of the coal imported from France and Belgium, some 160,000 tons was known to be of German origin.

The ballot of members of the engineering trade unions referred to in our issue for June 17 duly took place, and the result was announced last Wednesday, the figures being against acceptance of the employers' terms, 257,532; for acceptance, 125,014, or a majority against of 132,518. But conferences took place until early yesterday morning, and at the time of our going to press it is announced that a settlement has been arrived at.

The dispute in the cotton industry on the wages question has been satisfactorily settled and an agreement arrived at, signed by the chairmen and secretaries of the various employers and operatives' organisations, by which the operatives accept an immediate reduction on present-day wages of 60 per cent. on list rates, or 3*s*. 10*d*. in the £, and a further reduction in six months time of 10 per cent. on list rates, equal to 7*d*. in the £. The original demand of the employers was for a reduction of 95 per cent. on list rates, or about 6*s*. in the £. In a statement to the press, Mr. J. Smethurst, chairman of the Federation of Master Cotton Spinners' Associations, said he would like to add that the whole of the negotiations had been conducted in a most friendly and amicable way, and although there had been differences of opinion, these differences had never resulted in any wrong word being said by any member of each negotiating committee.

The Central Wages Board, comprising representatives of the railway companies and trade unions,

met in London yesterday to consider the quarterly revision of railwaymen's wages in relation to the Board of Trade figures of the cost of living. Since the last revision the figures for the cost of living have fallen 25 points, thus effecting an automatic reduction of wages of 5*s.* per week. No official statement was issued after the meeting, but it was stated unofficially that the proceedings were of an amicable nature.

In the course of the twentieth ordinary general meeting of the shareholders of Messrs. Richardsons, Westgarth and Co., Limited, held at Hartlepool last week, Mr. D. B. Morison, the chairman, stated that the average wage per hour was now practically three times greater than before the war, and a careful analysis of the firm's costs showed that it now took fully one-third more hours to do a given amount of work than before the war. Therefore, the actual labour cost of any given marine engine had increased four times.

In the matter of wages, Mr. W. A. Appleton, secretary of the General Federation of Trade Unions, writes in *The Democrat* for last Saturday, as follows: "It may be quite true that employers are attacking wages—some of them unfairly, some of them foolishly—but they in turn are being attacked by economic circumstances. In addition to making goods, they have to sell them, and unless they are successful in this phase of business there will neither be employment nor wages. National action such as was demanded a few days ago would stop both making and selling, and precipitate famine, for none of the food-exporting countries will send food to Britain unless her people can pay for it. The miners may continue the fight because there are many of them who believe that it is still possible to squeeze a few more drops from the sponge. Their success in bluffing the Government has been sufficient to warrant them making other efforts. There can, however, be no doubt as to the effect of their action upon other trades, most of whom are now realising that the Government can only give more to the miners by taking more from other workers."

The report on the Dyeing and Cleaning Trade, issued under the Profiteering Acts, 1919 and 1920, gives the following wages per week in the trade in question, which wages started on July 23, 1920, and were to remain in force until June 30 of this year: Men—Skilled dyer in charge of section of dye-house, 85*s.*; skilled dyer who can dye several colours, 80*s.*; dyer (one colour), 75*s.*; skilled workmen in dye-house, 70*s.*; wet and dry cleaners, 70*s.*; finisher, glazer and other skilled workmen, 70*s.*; labourer, 65*s.* Women and girls, 14 years of age, 16*s.*, rising to 21 years of age, 38*s.* Boys, 14 years of age, 16*s.*, rising to 21 years of age, 65*s.*, or full wages of group. The report concludes by stating (i) That the increase in the prices charged for dyeing and cleaning, as arrived at in the price lists submitted by various firms, are not excessive. (ii) That the percentage rates of profit on the turnover of those firms whose figures have been investigated do not on an average in the post-war period exceed those current before the war by more than 0·55 per cent. (iii) That while the committee are thus in agreement that the prices charged have not led to excessive profits in the trade as a whole, they are unable to recommend to the Board of Trade that any general list of prices should be approved under Section 1 of the Profiteering (Amendment) Act of 1920. (iv) Although they have no evidence indicating that the associations in this trade have tended to raise prices against the public, they consider that the future activities of this, in common with other, trade associations or combinations should be subject to some form of surveillance on the part of the Board of Trade in the interests of the public as a whole.

The report on the Pottery Trade has also been issued and its findings are to the effect (i) That the profits made in the industry would appear to be reasonable. (ii) That although associations exist in practically every branch of the industry, the committee have found no evidence that any attempt has been made to raise prices without reasonable cause. Nevertheless, they feel very strongly that having regard to the fact that in this industry there exist associations, controlling 60 per cent. or more of the industry, steps should be taken to safeguard the public interests. They therefore suggest that each of those associations which fixes selling prices should be required to obtain from its members at the end of each yearly period and deposit with the Board of Trade, a statement showing (1) the average trading profit and the average net profit in relation to the turnover of the industry in so far as it is covered by such association; (2) the average ratio of turnover to capital; (3) the average wages earned per hour of skilled, semi-skilled and unskilled labour. (iii) That the increases in the cost of material (especially coal), in freightage charges and in wages, have been the principal elements in determining the high prices now paid by the public.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—A survey of the local staple industries affords several sharp contrasts. Some of the manufacturing branches are well booked forward despite the coal strike, and would be engaged at high pressure but for the fuel shortage. The most notable of these is wagon making. In some instances, staffs are working overtime, though in other sections close on 70,000 employees are idle. Several useful contracts have been booked for locomotives for shipment. These have been secured in face of keen competition from foreign makers. In order to keep the price down to the lowest possible level, Sheffield engineering concerns have been compelled to resort to the purchase of Belgian castings, available at half the cost of local productions. This economy alone represents a difference in final cost of something like 850*l.* per locomotive. Another busy branch is that devoted to machine tool manufacture. In recent months export requirements have shown a marked expansion. Heavy arrears of orders have accumulated during the coal stoppage. Busy times are assured as soon as fuel supplies are available. Inquiries are circulating freely for mining and textile machinery, chiefly for shipment. In contrast, the steel-making trades are undergoing a period of acute depression. No business of magnitude is passing in crucible steel. Open hearth furnaces are idle throughout the South Yorkshire area. Prospects of improvement must depend greatly on the extent to which fuel prices can be revised to meet the changed economic position. Very little business is passing in raw materials. Blast furnaces are compulsorily idle. Accommodation lots are being secured from the Continent at greatly reduced prices. Producers of foundry iron have temporarily withdrawn quotations. Trade in ferro alloys has been reduced to a minimum. Crucible furnaces have sufficient stocks to work upon when production resumes.

South Yorkshire Coal Trade.—The failure of the coal stoppage to produce a wider paralysis in manufacturing operations is due directly to the extended adoption of oil fuel firing. This method has enabled the maintenance of electric supply to the lighter industries, and has afforded satisfactory results in heavy engineering and iron production. The position at several of the local collieries has become critical. Supplies from outside sources must be obtained if damage to pits by the suspension of pumping operations is to be averted. Business in house coal is practically at a standstill, municipal dumps having been exhausted. Nominal prices unchanged.

ANNUAL TABLES OF CONSTANTS OF NUMERICAL DATA.—We are informed that of these tables, which cover chemistry, physics and technology, and have been published since 1910 under the patronage of the International Union of Live and Applied Chemistry, the first part of volume IV (1913 to 1916, both inclusive), is now ready. The volume is to be in two parts. The prices to members of subscribing societies are, Part I, unbound, 75 francs, bound 90 francs; Parts I and II, unbound, 150 francs, bound 180 francs. These subscription prices remain open until July 30. Particulars and copies can be obtained from M. Ch. Marie, 9 Rue de Bagneux, Paris 6.

INTERNAL COMBUSTION RAIL CARS AND LOCOMOTIVES.—The Drewry Car Company, Limited, of 13, South Place, London, E.C.2, have issued a new catalogue describing the range of railway motor cars, inspection cars, mining and other locomotives, &c., which they manufacture. The firm is closely associated with that of Messrs. McEwan, Pratt and Co., Limited, of Burton-on-Trent, whose well-known internal combustion locomotives and tractors are now included in the catalogue. Steam locomotives up to 35 tons weight have also been added to the company's productions, which now comprise a very large range of vehicles, suitable for service of almost every kind, and for all climates. The company has cars in use in practically every part of the world, working sometimes at altitudes of 16,000 ft. or gradients of 1 in 16, and on all gauges up to 66 in. The unrivalled foreign experience of the firm is reflected in the illustrations of many of their vehicles under working conditions, which the catalogue contains.

REPORT ON EXPLOSIVES INDUSTRY.—There has now been issued by H.M. Stationery Office, a report on the Explosives Industry of this country, made by a subcommittee appointed by the Standing Committee on Trusts, under the Profiteering Acts. The report states that there are in the Industry, four Manufacturers' Associations which fix the prices of practically all the explosives, detonators and fog signals manufactured and sold in this country. Moreover, by reason of agreements with foreign manufacturers there is virtually no price competition. Foreign competition is found to be negligible, except in the case of sporting and rifle ammunition, and there is little prospect of it becoming severe in the near future. All the explosives companies in Great Britain, with the exception of three relatively small concerns, constitute one combine under the control of Nobel Industry, Limited. The Committee find that the agreement of the Board of Trade and the Treasury with the Nobel combine does not appear to afford a workable scheme of control or supervision, and they recommend that the powers of the Board of Trade should be supplemented by statutory authority to demand information necessary to enable the Board to supervise the operations of the combine and to act for the protection of the consumer.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The turn of events in the coal trade trouble, whilst not at all unexpected, was very welcome and has materially improved the tone in iron trade circles. Firms who make their own pig-iron for consumption are preparing to blow in idle furnaces almost immediately, and some are expected to be in operation once more at the beginning of the week, but it is felt that cost of production must be very substantially lowered before resumption of make for the open market can be looked for. The better qualities of Cleveland pig-iron are exceedingly scarce. Some producers have considerable stocks, but these are sold, and only one firm of makers can offer foundry iron for sale. There is now no attempt to put through foreign business in Cleveland pig-iron. To home customers, No. 1 is 140*s.*, No. 3 G.M.B. 135*s.*, and No. 4 foundry 134*s.* The common kinds are quite plentiful, and producers are keen to sell from their still heavy stocks at 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite Iron.—In the East Coast hematite branch the most interesting event is a further fall in export price. Makers are under no obligation as to prices they may charge to foreign buyers, and they are keen to secure export orders, with the result that they freely offer Nos. 1, 2 and 3 for abroad at 140*s.*, and even this figure does not tempt buyers. For home sales the agreed on minimum figure of 160*s.* for mixed Nos. is loyally adhered to.

Foreign Ore.—There is absolutely nothing passing in foreign ore. Consumers have very heavy stocks, which continue to accumulate with arrivals of odd cargoes in fulfilment of old contracts, but with blast furnaces re-starting, stocks now promise to be drawn upon.

Coke.—As yet there is not much doing in coke. Prices are expected to fall.

Manufactured Iron and Steel.—Sales of finished iron and steel are few and small, but improvement in demand is looked for notwithstanding continued underselling by foreign manufacturers. Re-starting of several works will not be long delayed. A 3*l.* fall in common iron bars is no more than was expected. This reduces them to 16*l.*; whilst among other principal market quotations are: Steel billets, 11*l.* 10*s.* to 12*l.* 10*s.*; steel boiler plates, 21*l.*; steel ship, bridge and tank plates, 15*l.*; steel angles, 14*l.* 10*s.*; heavy steel rails, 15*l.*; fish plates and sleepers, 20*l.*; and corrugated galvanised sheets, 22*l.*

KITCHEN'S REVERSING RUDDER COMPANY, LIMITED.—This company informs us that the results of one of their reversing rudder sets, which they supplied about a year ago to the order of the Norwegian Hydrographic Office for installation in one of their motor survey launches, having proved so highly satisfactory, the department have decided to adopt the rudders as a standard equipment for all their boats, and a sum of money has been voted for this purpose in the estimates for the ensuing financial year.

MESSRS. DAVY BROTHERS, LIMITED, NEW WORKS.—On Monday, June 20, the new works erected by Messrs. Davy Brothers, Limited, at Darnall, near Sheffield, were formally opened. These works are situated on a site of 25 acres, between Darnall Railway Station and the Handsworth-road, or which it is proposed eventually to build a complete engineering works. At present the light machine shops are completed. These have an area of 64,000 sq. ft., and consist of two main bays, 60 ft. wide and 30 ft. high to the crane rails, and a lean-to 30 ft. wide. All are 400 ft. long. Five overhead cranes, ranging in capacity from 2 tons to 20 tons, and numerous gib cranes facilitate the handling of the material to and from the machines.

INDIAN TIMBERS AND PAPER MATERIALS.—Enquiries into the possibility of increasing the utilisation of Indian timbers in this country and of making use of Indian paper materials have been carried out in connection with the Indian Trade Enquiry undertaken by the Committee for India of the Imperial Institute, and the reports have just appeared in a volume published by Mr. John Murray under the title "Reports on Timbers and Paper Materials" (price 4*s.*). Hitherto the exports of timber (other than teak) from India have been relatively small, owing chiefly to the existence of a large local demand. It is considered, however, that there would be an opening for an extended export trade to the United Kingdom in certain hardwoods, which would be of value for decorative and other purposes, and are at present little known in this country. The characters and uses of a number of such timbers are described. In the section on paper materials a general statement is given as to the world's pulp and paper-making industry, special reference being made to the position in India. Details are included as to the possibility of utilising Indian bamboos and Savannah grasses for paper making, and the opinion is expressed that in these two materials India possesses valuable resources which occur under circumstances not unfavourable for their commercial development. It is considered that the immediate aim in the development of an Indian paper-pulp industry, which should receive every encouragement from the Government of India, should be to reduce, and finally to replace (as far as possible) by Indian supplies, the large amount of pulp and paper imported into that country. It is believed that the replacement of imports by Indian produce would be quickly followed by a surplus production which would be available for export.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Trade Position.—Now that we are within an ace of the settlement of the miners' strike—the most disastrous of its kind for many years—we are faced with rather serious trouble in the engineering trade. It is fervently hoped here, that a way may be found to settle the difference now prevailing and that another trade stoppage may be prevented. Every industry throughout the length and breadth of the land is suffering severely from the trouble in the coal trade and hundreds of thousands of pounds of good business has been lost. Demand all round has long since ceased and inquiries for almost anything at all are at the very minimum. Our overseas customers have had to go elsewhere for their requirements, and as everyone knows, these buyers will require to be won round again and the job cannot be accomplished in a day or without a great amount of tact and ability on the part of our sellers. Lower prices will be necessary for one thing, and if iron and steel material has to be sold at considerable reductions on even the present quotations then much cheaper coal must be obtained. Should the miners return to work next Monday, as is now anticipated, it is highly probable that a great many establishments will recommence operations immediately thereafter and ignore the annual holidays which are due in a fortnight.

Scottish Steel Trades.—Once again have hopes been raised that the coal strike is nearly over, but few will do anything in the way of making final arrangements to re-open their works until it is known that the miners are actually back in the pits again. The Scottish steel-makers having made another cut in prices, intimated last week, are now waiting to see if fresh business should result, but so far buyers have not put forward many inquiries. In order to meet the very severe foreign competition which prevails, buyers say that considerably lower prices must yet prevail to induce them to place business at home, but until the coal trade recognises the fact and offers cheaper fuel, the steel producer cannot do much better without working at a heavy loss. Steel sheets are on the turn, more active, and various lots have lately been sold ex-stocks.

Scottish Malleable Iron Trade.—In the West of Scotland malleable-iron trade, there is still nothing doing either in the way of fresh business or in production, but the latter may be an accomplished fact very soon now. In order to induce buyers to come forward the bar iron makers decided at the end of last week to lower prices by 3*l.* per ton, and the quotation for "crown" quality is now called 16*l.* per ton, delivered at Glasgow stations. This new figure, while marking a fall of 11*l.* 10*s.* per ton since the beginning of this year, is exactly 1*l.* more than half the price that "crown" bars were at a year ago when the record figure of 30*l.* per ton was touched. So far reports do not acknowledge much additional bookings, but when it is remembered that steel bars from the Continent can be bought in this country for between 9*l.* and 10*l.* per ton, it is not to be expected that there will be an immediate run on the home article, despite the fact of its superiority for certain purposes. With the resumption of business however, things will very likely take a turn for the better and when fuel eases off a bit the home prices will probably be shaded further and order books will get filled up.

Scottish Pig Iron Trade.—The situation in the pig iron trade of Scotland is still unchanged, and although there are prospects of the miners returning to the mines on Monday next, there is little disposition on the part of the owners of blast furnaces to hurry in the re-kindling, and little will be done in that direction until the likely price of fuel is ascertained. It is essential that that must be cheap in order that cheap pig iron may be made available for the many users of it. Business is meantime made up of small parcels of ex-stock, but in the case of foundry iron there is extremely little to be secured, as most stocks are about exhausted.

ROYAL SOCIETY OF ARTS.—The one-hundred and sixty-seventh Annual General Meeting of the Royal Society of Arts was held yesterday afternoon, Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, presiding. It was reported that H.R.H. the Prince of Wales had accepted the office of Vice-Patron of the Society. The Patron is H.M. the King, and the President is H.R.H. the Duke of Connaught. The following medals have been awarded for papers read during the Session: Major-General the Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., "Forestry"; Colonel Robert J. Stordy, C.B.E., D.S.O., "The Breeding of Sheep, Llamas, and Alpacas in Peru, with a view to supplying improved Raw Material to the Textile Trades"; Andrew Francis Baillie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various parts of the World"; Wm. Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice"; Sir Kenneth Weldon Goadby, K.B.E., M.R.C.S., D.P.H., "Immunity and Industrial Disease"; William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India"; The Hon. Sir George Curtis, K.C.S.I., "The Development of Bombay"; A. H. Ashbolt, Agent-General for Tasmania, "Industrial Development in Australia during and after the War"; Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol." The number of candidates entering for the Society's Examinations this year was a record, the total being 55,181. The new Council for 1921–22 was elected; and also thirty new Fellows making a total of 285 for the year.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—The end of the prolonged strike has resulted in some revival of interest in the Cardiff coal market, and there are several inquiries floating about, but actual post-strike transactions are very few, and both sellers and buyers are hesitating to commit themselves owing to great uncertainty which prevails as to the immediate future conditions governing the coal export trade. So uncertain is the outlook, even assuming a resumption of work next week, that it has been found difficult, if not impossible, to enter into even tentative business arrangements. In the circumstances it is really useless to give quotations on which any reliability can be placed. For the moment, operators are content to wait the course of events, and the extent of the demand for, and supplies of, coals for export. In some exceptional cases shippers are arranging for ships for the conveyance of coal to foreign destinations, including cargoes for the Plate.

Iron and Steel Trades.—The South Wales iron, steel and tinplate industries are in a parlous plight. The supply of fuel, in itself, would not greatly improve matters, and the chief factor in the situation is the question of costs to enable makers to compete successfully with foreign competitors. The general opinion is that there can be no permanent appreciable improvement until the price of coal is reduced to a more economic level than that which ruled prior to the strike. Many works are comfortably off in the matter of raw materials, but even so, it is felt that fuel costs must be diminished, as in order to rehabilitate the industries the price of products will have to be "cut" sufficiently to attract business.

SIROCCO ENGINEERING WORKS, BELFAST.—H.M. the King, during his visit to Belfast, on June 22, conferred the honour of a Knighthood of the British Empire Order upon the Chairman and Managing Director of these works, Sir Samuel Davidson, K.B.E. The works are owned by Messrs. Davidson and Co., Limited.

MESSRS. C. P. SANDBERG AND THE CHINESE RAILWAYS.—Messrs. Sandberg informs us that the Ministry of Communications of China, which controls all the Chinese railways, has appointed the firm their Honorary Technical Advisers. The appointment is embodied in a dispatch from the Chinese Ministry of Communications. Messrs. Sandberg are the consulting and inspecting engineers to the majority of the Chinese Government Railways. The Ministry of Communications has recently requested them to train a number of engineers in Europe and America, and they understand that these engineers are now being selected.

LLOYD'S REGISTER OF SHIPPING.—Mr. James T. Milton, M.Inst.C.E., who has held since 1890, the position of Chief Engineer Surveyor to Lloyd's Register, has asked to be allowed to retire from that office on September 30, on account of advancing years, and the Committee have acceded to his desire. Mr. Milton's connection with Lloyd's Register will not, however, be completely severed, arrangements having been made by which the Committee will be able to avail themselves of his wide knowledge and experience, should occasion arise. The Senate of the University of Durham recently decided to confer upon him the Honorary Degree of Doctor of Science; the ceremony took place last Tuesday, June 28. The Committee of Lloyd's Register have appointed Mr. H. Ruck-Keene, M.Inst.C.E., who has been Mr. Milton's assistant for the past 12 years, to succeed him in the office of Chief Engineer Surveyor.

SCHOLARSHIPS IN NAVAL ARCHITECTURE AND MARINE ENGINEERING.—At a time when so much interest is being taken in our scientific and engineering progress it may be opportune to call attention to the scholarships that are now available for apprentices and students in shipbuilding and marine engineering, ranging in value from 100*l.* to 150*l.* per annum, which are offered annually by various firms or by endowment, and are administered by the Council of the Institution of Naval Architects. They are awarded either on the results of the Board of Education's examinations in specified subjects or on certain papers set in the matriculation or entrance examination at the Colleges or Universities where the scholarships are usually tenable, viz.: Glasgow University; Liverpool University; Armstrong College (Newcastle-on-Tyne); City and Guilds (Engineering) College (South Kensington). Some of these scholarships have been in existence for upwards of twenty years, while others have only recently been established, but the number of candidates that come forward and compete is not large, having regard to the value of the scholarships, and to the great number of apprentices and students who are engaged in shipbuilding and marine engineering. It may be pointed out that all the students who have won these scholarships in the past have uniformly succeeded so far in making good in their professional career, and it is felt that further attention may usefully be called to this subject in order that the field of candidates may be broadened and that greater interest may be taken by those who desire to promote the welfare and progress of our young shipbuilders and engineers. Two scholarships in naval architecture, and two in marine engineering are now offered for competition, the entries for which close on July 31. Full particulars and forms of application may be obtained from the Secretary of the Institution of Naval Architects, 5, Adelphi Terrace, London, W.C.2.

NOTICES OF MEETINGS.

THE ROYAL INSTITUTION.—Monday, July 4, at 5 p.m. General meeting.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Friday, July 8, at 11 a.m. Meeting at Birmingham. 11 a.m., members meet at the central entrance of the Council House, where special tramcars will be in readiness to convey members to (A) Pebble Mill-road (120 ft. wide), or (B) Tyburn-road (150 ft. wide, partly constructed), both of which have tramways laid on sleeper track. (Notice of preference must be given to the Hon. District Secretary.) 2.30 p.m., welcome by Sir David Brooks, G.B.E., Deputy Lord Mayor. 2.45 p.m., extraordinary general meeting. Discussion of the following paper: "Extension and Co-ordination of Arterial Road Schemes in the Midlands." by Mr. H. H. Humphries, City Engineer, Birmingham.

BRITISH ENGINEERING STANDARDS ASSOCIATION. AUTOMOBILE STANDARDISATION.—The Automobile Sub-Committees of the British Engineering Standards Association are already making a start at actual standardisation work. Certain proposals for standardisation in connection with small fittings which were put forward some little time ago by the Association of British Motor Manufacturers were considered at a meeting of Sub-Committee 3 under the chairmanship of Mr. W. D. Williamson on the morning of June 30, that date being chosen in order to take advantage of the presence in London of the representatives of the motor industry, who are attending the meeting of the Association of British Motor Manufacturers. The work will be divided into suitable sections and dealt with in accordance with the usual procedure of the Association.

SIXTEEN UNITED STATES GOVERNMENT VESSELS TO BE SCRAPPED.—The following letter in regard to scrapping obsolete steel vessels has been sent to scrap firms by David Potter, paymaster-general of the Navy, says *The Iron Age*, New York: "The Navy is faced with the problem of disposing of about 16 large steel vessels, including four obsolete battleships of about 12,500 tons displacement each, and old monitors and cruisers of lesser displacement. These vessels are located at various yards along the Atlantic Coast. They are probably of no value except for scrap purposes, and it is the desire of the Navy to interest companies who would be able to buy these vessels singly, or in groups, with a view to breaking them up for redistribution as scrap. Considerable work of this nature has been done by English firms in connection with the disposition of English Navy vessels. In view of the extent of the operation, it is felt that it could be made attractive enough to justify the formation of a company for this particular purpose. The Navy will, therefore, appreciate an expression of your views and the possibilities of your company in this connection, and will be glad to furnish any additional information, orally or by letter, on request."

GERMANY'S POWER RESOURCES.—Under the impetus of coal shortage, a great coal saving movement had been started during the war all over Germany, says *Power*, New York. Lignite and even peat were being used in power plants, in spite of the costly additions of equipment required for the purpose; and a large number of water-power projects, some of which were of almost unheard-of magnitude, were studied. This policy has lately suffered a severe check and reaction has followed. The reason for this is the latest estimate of the country's power resources, outlined in the following tables, wherein the water power has been estimated by assuming all prospects in view or under exploitation for 1,000 years, corresponding with the estimated life of the coal deposits.

Germany's Power Resources.

	Tons.
Bituminous coal	305,000,000,000
Lignite	13,400,000,000
Peat	850,000,000
	Kw.-hr.
Water power	7,600,000,000,000

Equivalent Value in Bituminous Coal of Germany's Power Resources.

	Tons.	Per cent.
Bituminous coal	305,000,000,000 or	95·4
Lignite equivalent	4,200,000,000 or	1·3
Peat equivalent	340,000,000 or	0·1
Water-power equivalent ...	10,300,000,000 or	3·2
Total	319,840,000,000	100

The second table was compiled by assuming 1 lb. of bituminous coal equivalent in effective energy content to 3·14 lb. of lignite, 2·47 lb. of peat and 0·33 kw.-hr. The reason for the Government's change of front is evident from these figures, for there can be little use in trying to save bituminous coal by burning peat when there is one thousand times more coal available than peat. It must not be assumed, however, that the Government has refused to consider all water-power developments; but the greatest caution is advised in weighing the relative merits of coal and water power, and it is emphasised that the decision should rest exclusively upon the actual cost of producing energy by the two methods and not on any sentimental considerations of fuel conservation, for the nation's financial resources are in greater danger than her coal supply.

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

(*For Description, see Page 2.*)

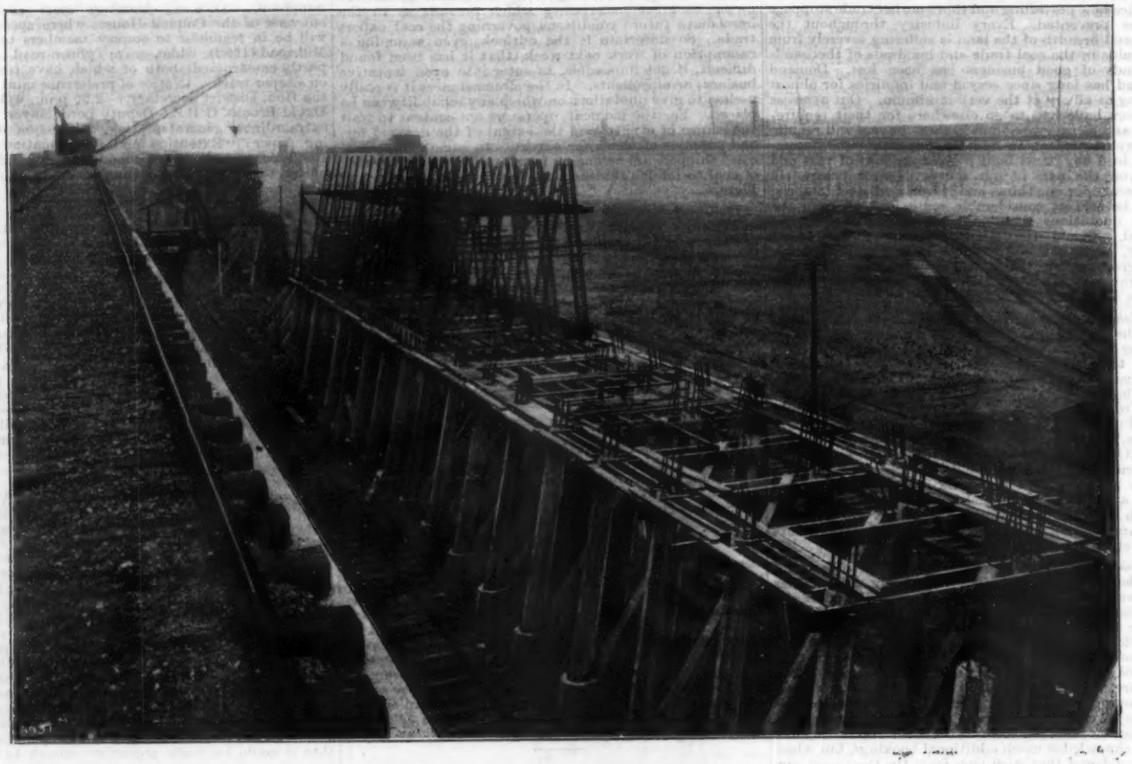


FIG. 19. THE SOUTH SIDE CRANE JETTIES DURING CONSTRUCTION.

DEVELOPMENT IN THE FEDERATED MALAY STATES.—The Federated Malay States Government is losing no opportunity of securing expert advice on the development of the country. The services of Mr. C. C. Reade, of the Town-Planning Department of South Australia, have been requisitioned for a year to give general guidance on town-planning. Professor Gilbert J. Fowler, D.Sc., of the Indian Institute of Science, Bangalore, is at present occupied with the question of sewage disposal in the four largest towns, Kuala Lumpur, Ipoh, Seremban, and Klang. Professor Fowler is eminently qualified to report on this subject, and in 1918 he performed a similar service for Shanghai. Mr. F. Bolton has also recently visited the country to give advice on the provision of electric power and light in the larger towns. Apart from town-development, the question of Irrigation has been receiving attention, Mr. C. E. Depuis, who has seen long service in the Irrigation Departments of India, Egypt and the Sudan, recently spent six months in the country reporting on existing and proposed systems of drainage and irrigation.

TRAINING OF CHINESE STUDENTS.—Trade Notes on the above subject, communicated by H.M. Commercial Counsellor at Shanghai to the Department of Overseas Trade are to the following effect. *United States of America*: The Chinese Chamber of Commerce has been notified by some American firms in the United States, that for the purpose of further promoting Sino-American commercial relations, leading American engineering and other houses are willing to admit Chinese students to learn modern business methods after completion of their studies in American schools and colleges. The American firms promise to pay reasonable salaries to these Chinese. *Belgium*: According to a Chinese paper, the Belgian Government is planning to establish a university at Brussels for Chinese students and has approached the Chinese Minister at Brussels to obtain the views of his Government regarding the project. *Sino-French Engineering School at Shanghai*: The foreign commissioner has been notified by the Ministry of Education to the effect that at the suggestion of the French Government, the Peking Government will re-organise the former German commercial and engineering college in the French Concession of Shanghai for the purpose of training commercial students for the development of Sino-French commerce and industry. The initial and maintenance expenses of the said college will be equally borne by the Chinese and the French Governments. The French director is a prominent French resident in Shanghai who has been canvassing subscriptions in France, while the Chinese Government will provide a sum of 150,000 dols. The college will be called the Sino-French Engineering and Commercial College, and its chief aim is to train Chinese engineers on French lines with the hope that France may receive a very large share in the coming industrial development of China. The civil governor of Kiangsu has been instructed by the Peking Government to make preparations so that the proposed college can be established as soon as the French promoter returns to Shanghai.

FIG. 20. ONE OF THE COMPLETED JETTIES.

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

(*For Description, see Page* 2.)

FIG. 7. GOLIATH CRANES USED IN THE CONSTRUCTION OF THE DOCK.

FIG. 8. EXCAVATOR AT WORK ON THE DOCK SITE.

(*To face page* 4.)

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

(*For Description, see Page 2.*)

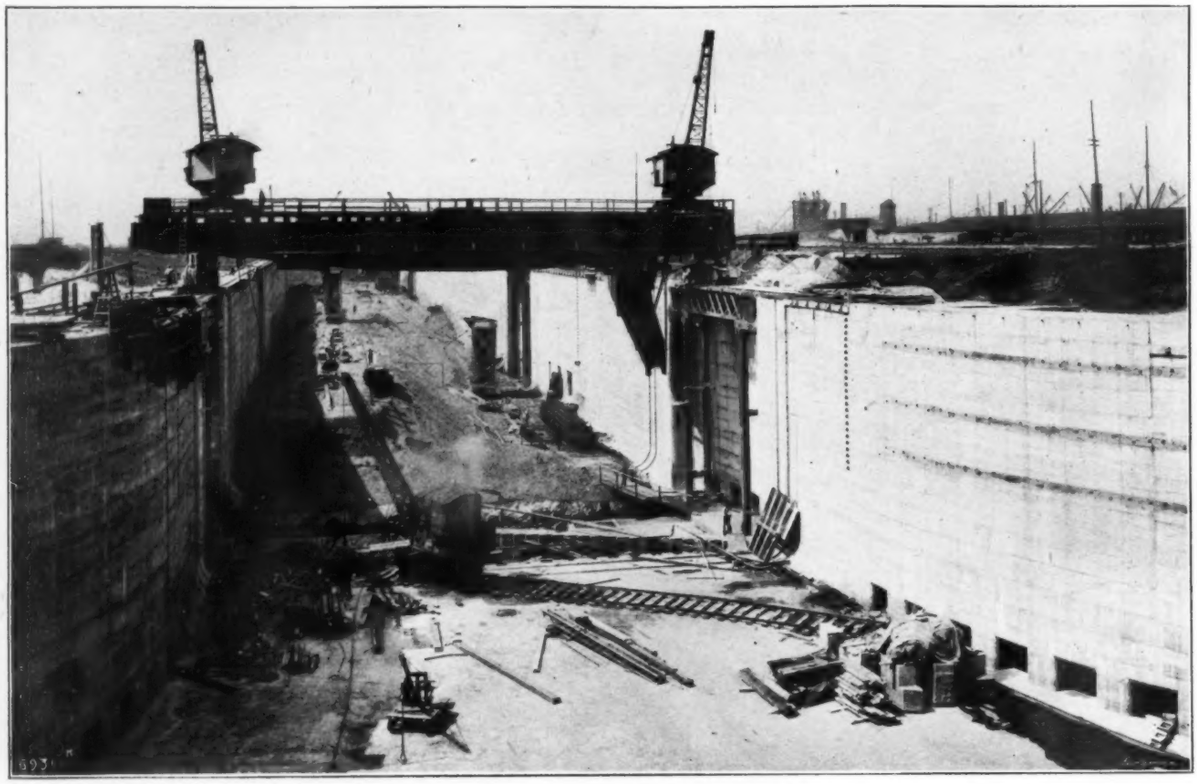


FIG. 9. ENTRANCE LOCK DURING CONSTRUCTION.

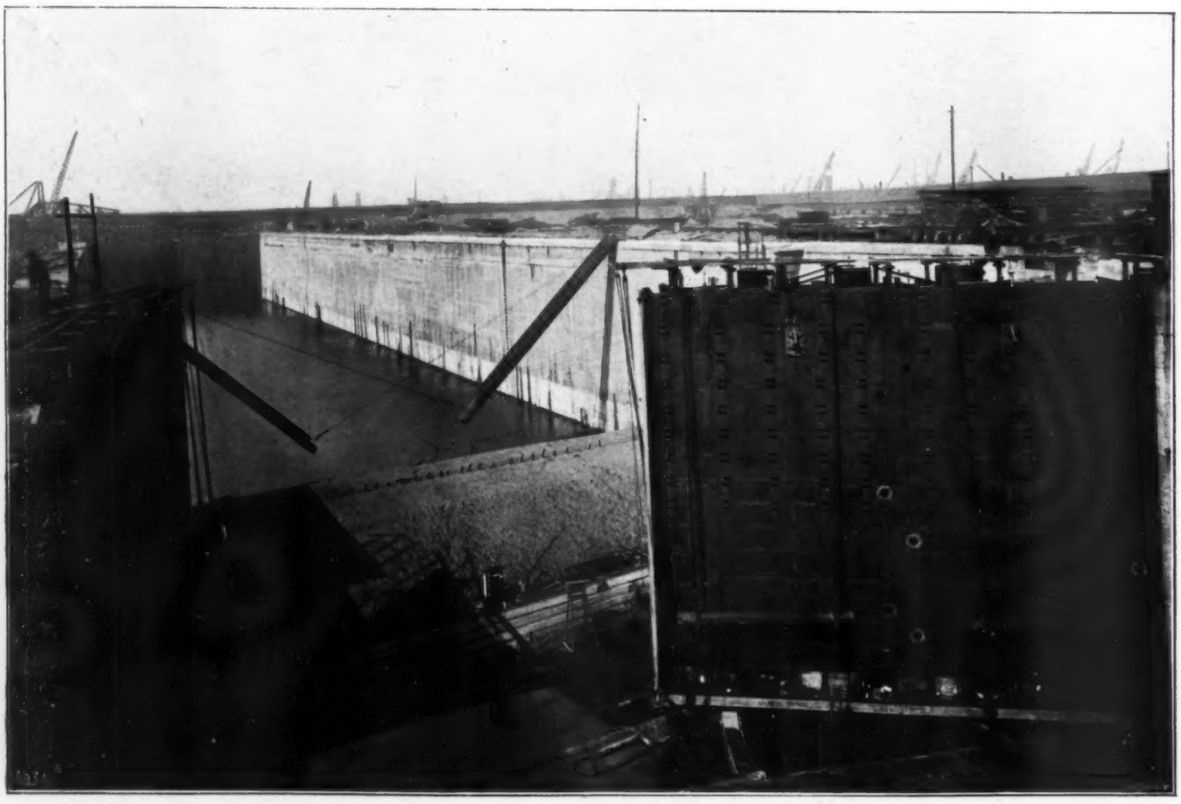


FIG. 10. ENTRANCE LOCK AND GATES NEARING COMPLETION.

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

(*For Description, see Page 2.*)

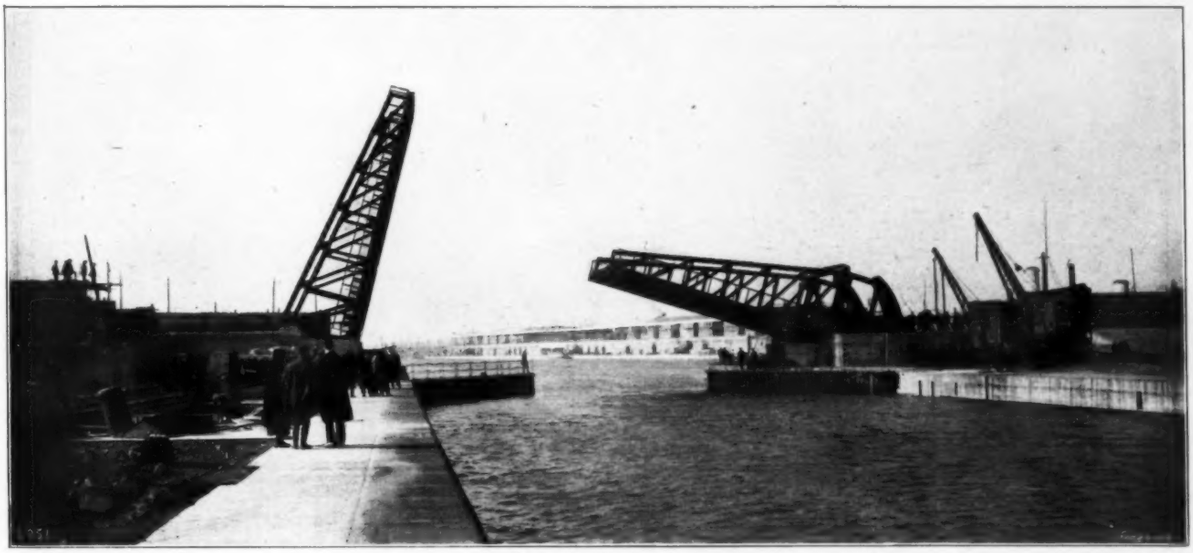


FIG. 11. ENTRANCE LOCK AND BASCULE BRIDGE.

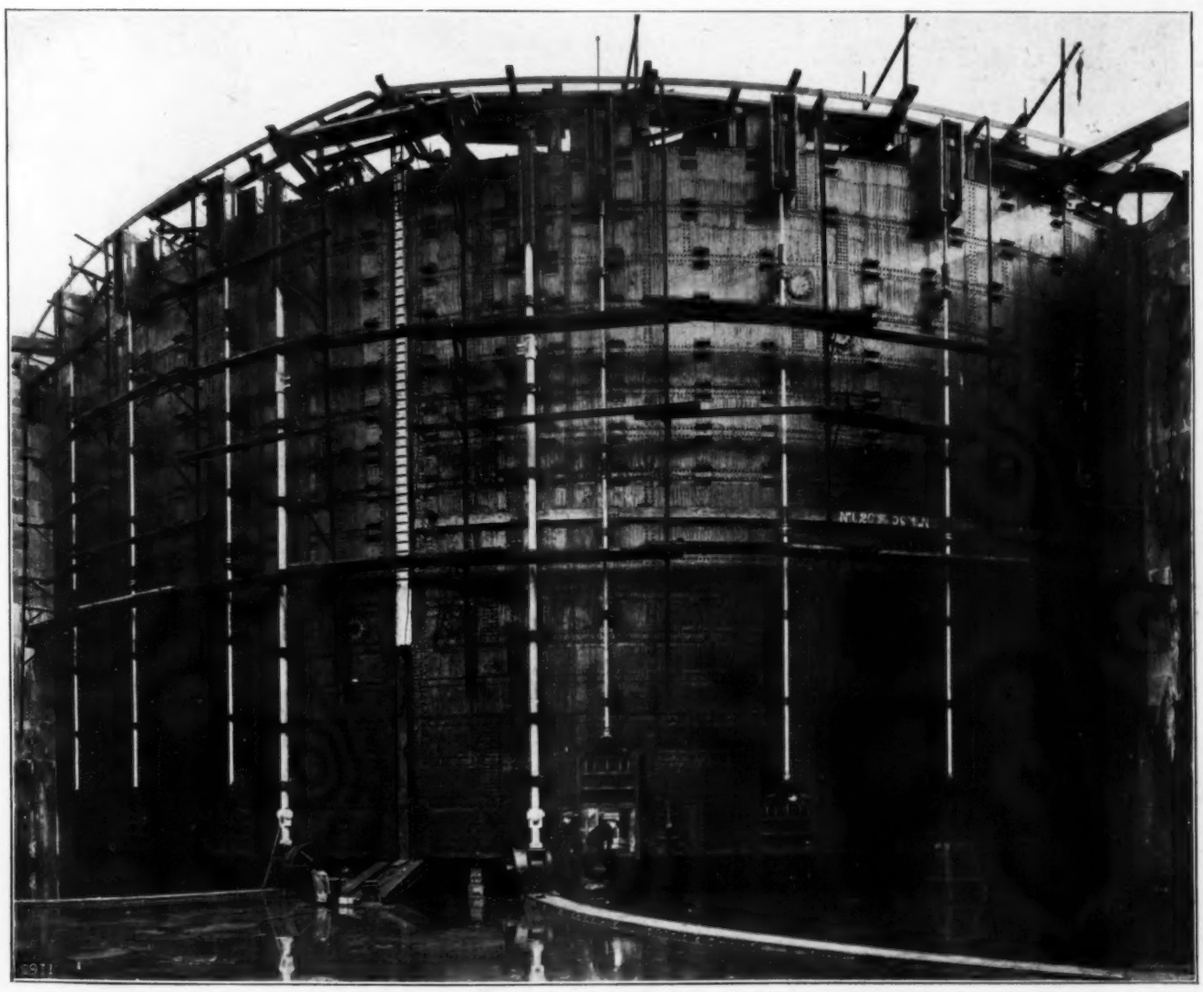


FIG. 12. GATES OF THE ENTRANCE LOCK.

THE ROYAL ALBERT DOCK EXTENSION, LONDON.

(*For Description, see Page 2.*)

FIG. 13. SWING BRIDGE NEARING COMPLETION.

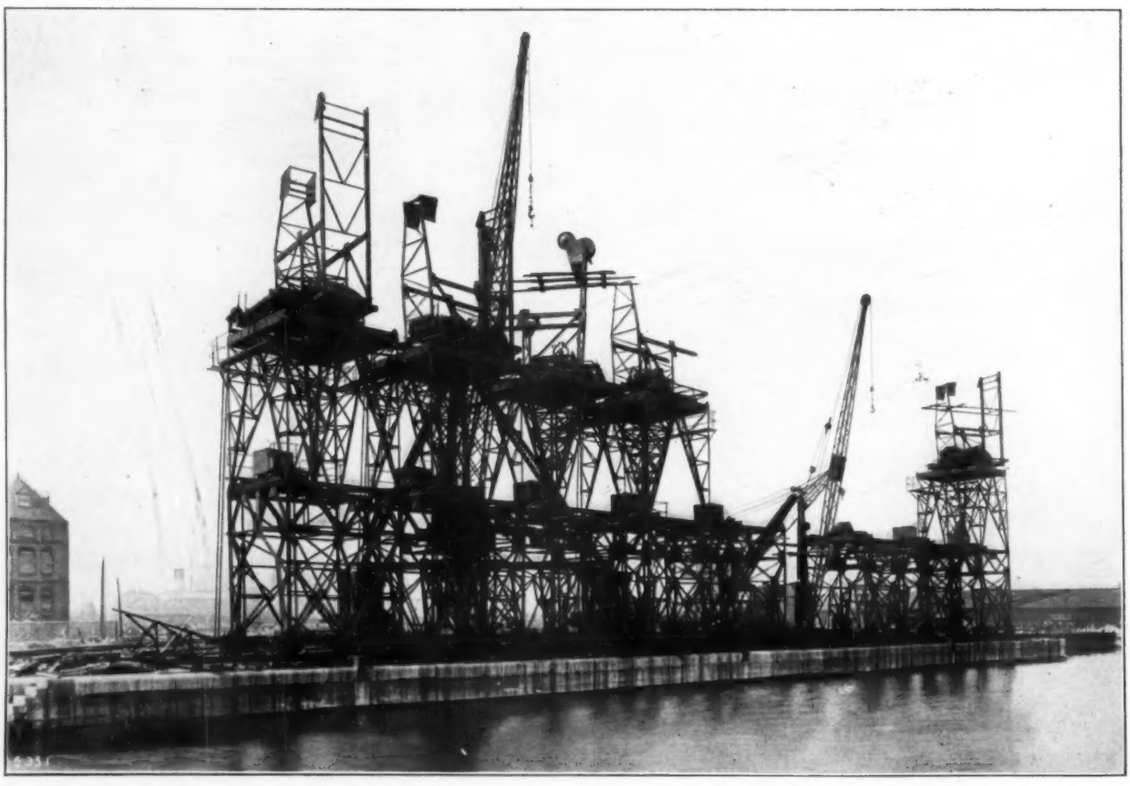


FIG. 14. WHARF CRANES DURING CONSTRUCTION.

(*To face page 5.*)

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The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICE.

The Publisher begs to announce that from the 1st of July the price of "ENGINEERING" will be reduced to

1s. per copy.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 15.

ENGINEERING.

FRIDAY, JULY 1, 1921.

FOSTERING ORIGINALITY IN SECONDARY SCHOOLS.

WHEN discussing "the educational outlook" the other day, Sir Henry Craik gave a warning against excessive expenditure on education. This warning was endorsed by the Professor of Education in the University of Edinburgh. As chairman of the education authority the professor had been face to face with outlays and results, and, in his opinion much of the money spent on school bursaries and continuation work was thrown away. Admittedly there are few schemes for promoting the public good which are free from waste, but although it might be easy to demonstrate the unfruitfulness of expenditure on education in, say, half the individual cases receiving national subsidy, it might not be at all easy to gauge the full gain to the State from even lavish outlay on the other half. In appraising the outcome of national education we get little help from statistics. Facts and figures relative to public libraries, police courts, church going, entertainments' tax, university enrolments and the decrease of illiteracy among the electorates, while not without meaning, may mislead through difficulties of interpretation with regard to the problem in hand.

We have long held the view that concentration of educational effort on skilfully selected youths was of more importance to the nation than ambitious, all-embracing schemes, which pleased official minds, supplied fine platform phrases and satisfied the aspirations of teachers in higher and continuation schools. So Sir Henry's words brought no surprise; and, when it is remembered that this distinguished scholar and most devoted educationist from whom the warning comes, controlled, not so long ago, the school system of Scotland and still influences the education trend of this country, the warning has added gravity and significance. There is in it almost the confession that his one-time vigorous recruiting beyond the standards, and his declared belief in the adequacy of an all-round, well-balanced, liberal curriculum, have not been quite so productive, in the best economic sense, as had been anticipated. Be that as it may it can be assumed that any suggestion either of, reduced expenditure or of increased spirit and work in schools is not out of place at the present time.

Except for a relatively small number who aim at professional careers involving high academic attainments, long-drawn-out secondary courses arranged for youths up to and over 18 years of age are of doubtful value. Fine youths these are, strong and hearty, revelling in games and little concerned about the future. They will make first-rate soldiers. That, however, is not an educational aim. Here, then, we have an opportunity for exercising a wise economy. Into State-subsidised secondary schools there should be free entrance for skilfully-selected youths of quality. From time to time there should be applied a well-considered system of further selection. It might also be of immense advantage to the moral fibre of the youths themselves, and somewhat of a safeguard to the State, if those receiving high theoretical training and all the privileges of secondary schools, had to give a portion of their time to essential manual work—it might be, *e.g.*, in the mills, the mines, the transport services or the engineering shops. Have we not here the nucleus of a National Service Cadet system with a promise of advantage to national stability?

Costly continuation-class schemes, as the Edinburgh professor contends, should not be forced upon all youths. The compulsory character can be made to apply merely to attendance and extravagance; for the education there can be no guarantee. At present there are few towns without some facilities for after-school education. An increased demand will be met as it arises. Our objection is to the costliness of a compulsory scheme in view of the lack of argument or evidence in support of its economic value. It looks as if a wave of emotion had swept over education ministers and schoolmasters. How readily one is stirred with the trite statements that teaching is "a noble occupation" and that its purpose is "to train the individual in self-realisation for the service of the community." We enter no dissent, but we do not forget that the teacher, as ordinarily defined, has only a small share in the process, and that the regimentation and routine of school work, with formal certificates as the objective, have little to do with the self-realisation of the pupil.

Thomas Fuller, a seventeenth century divine, wrote "He (the teacher) studieth his scholars' natures as carefully as they their books, and ranks their dispositions into several forms." The first of his "forms" consists of "those that are ingenious and industrious." On them he places hope, and, for them he recommends not compulsion but "all gentleness." Of lower groups, "out of which come quite useful citizens," he says, "all the whetting in the world can never set a razor's edge on that which hath no steel in it." To-day, more almost than at any time since Fuller's pronouncement, there is need for the State to discern and foster "ingenious and industrious natures." This must be the dominant idea in our reconstructed higher school schemes, but, although salvage of money may be effected thereby, the state must see to it that, whatever their origin and circumstances, youths, who have ability, balance and grit, will be carefully sought out and guided along lines on which their intelligence and character can become effective. That is how "democratization of education" appeals to us. The story of our "English worthies" (including, of course, that of eminent Scots) attests its practicability, and Lord Haldane hopes to give his remaining years to the cause.

Holding these views we have pleasure in learning of an experiment for the fostering of individuality and initiative, which, through the liberality of a successful American engineer, has been started in the Glasgow High School of Science (Allan Glen's school). Like Thomas Fuller, Doctor of Divinity of Cambridge, Mr. John Younger, of Cleveland, Ohio, wants to get at and give a hand to ingenious and industrious youths. This is the method he adopts. Each year, for a trial period of three years, he will place at the disposal of his old school 100 dols. for the encouragement of originality among pupils in the advanced science section. The Younger Research prize will be awarded on the recommendation of experts to the boy who has on his own initiative done the most ingenious work quite outside that of the normal classes.

At first glance some doubt may arise as to the service of this benefaction to boys at school. But the school concerned has a large science department with courses of study fitting into the engineering and chemistry requirements for university degrees The well-equipped laboratories for practical work in general physics, chemistry, electricity and applied mechanics, have been in operation for many years, and excellent work of many kinds has been done in the workshops for wood and iron. The donor of the prize had four years' training in this school. He feels that his career has been influenced by that training. Recognising, however, that where an educational course is well organised in a school and faithfully administered, up to a formal standard, by accomplished specialists there is some risk of a certain suppression of individuality and perhaps even some quenching of enthusiasm, he has made the bold proposal of offering a school prize for work done quite independently of earnest teachers and stereotyped programmes.

Of the value of the experiment there can be little doubt. Among the youths preparing to do, in the near future, productive national service, there are bound to be some who can pass without hurt beyond the routine of school work and find for

themselves problems on which to apply their theoretical knowledge and practical skill. That is the meaning here attached to the word "research." The donor does not look for anything revolutionary. He is not disturbed by Horace Smith's definition of originality as "unconscious or undetected initiation." Before him is the vast array of inventions, small and large, which in the first half of last century gave Britain the lead in many industries and the 1001 smart labour-saving devices and cleverly-modified machines with which America now supplies other countries. He believes in fresh young minds and the aim of the gift is to stimulate observation, curiosity, imagination, to evoke interest in the how and why of things and to encourage "ingenious and industrious natures" to find expression in the pursuit and testing of new things and new methods. The science training they have had will quickly check will-of-the-wisp excursions and the subjects they have been studying will no longer be merely of some interest in themselves or for certificate-earning, but they will be also, and above all, means to useful production, an objective which the war and its sequels have brought so threateningly before the minds of all sane people.

THE INSTITUTION OF CIVIL ENGINEERS. ENGINEERING CONFERENCE.

THE Conference of the Institution of Civil Engineers opened at 10 a.m. on Wednesday with a well-attended meeting in the Great Hall of the Institution, Great George-street, Westminster. The preliminary proceedings, of which we give an account below, occupied rather more than the allotted time, and the subsequent discussions at the sectional meetings were consequently somewhat curtailed and in some cases had to be adjourned. We commence this week a full report of the discussions, but are compelled to confine this to Section I and the joint meeting of Sections II and V. For the other sections we are able this week to give only a brief summary of the proceedings, a full report of which will appear in our next issue. The Conference met again yesterday (Thursday) and is again in session to-day. Reports of these meetings will appear in subsequent issues of ENGINEERING, together with the short papers introducing the subjects discussed. We may conclude this introductory note with the statement that a large number of those attending the Conference availed themselves of the various visits arranged for the afternoons, and that on Wednesday evening Sir A. B. W. Kennedy, F.R.S., showed by means of the lantern the photographs which he had taken of the war areas in Flanders and France.

OPENING PROCEEDINGS.

The President, Mr. J. A. Brodie, in opening the proceedings, said the Conference was the fifth held since 1897, and was long overdue. The short papers which would be submitted to the various sections of the Conference covered a very wide range of subjects, most of them dealing with solutions or attempted solutions of problems, which was often the most interesting work of the true engineer. While engineers considered and discussed subjects dealing more particularly with engineering and the sciences in close relation therewith, it might be that they were too apt to leave to others many matters which affected them very seriously, often in common with all other citizens, and in the consideration of which their training and experience should possess a special value. To take a case in point, was it not possible to discuss with great advantage the possibility of providing suitable machinery for the proper control and handling of questions which led up to the cessation of production, particularly in branches of work which were vital to the nation. Thoughtful people, amongst whom, of course, he included engineers as a class, could not consider it creditable that the treatment of disputes and their consequences should be left so largely to chance as was the case in this country at present. In addition to his technical and scientific training, the competent engineer must have a special and intimate knowledge of workmen gained by actual contact with them in the works. He must understand their point of view, their capabilities for producing work, and their possibilities generally, and he was not likely to be less sympathetic with their legitimate aspirations than other classes of the community, but rather more so.

The engineer who was continually accustomed, as part of his work, to find and work out solutions of difficult problems, would appear to be specially suitable to deal with and to find methods of treating the troubles which arose between workmen and employers. He was quite sure it was not beyond the capacity of engineers to evolve a method of dealing with such differences, and he made the suggestion that the formation of an engineering committee, charged with the duty of carefully investigating the conditions surrounding the whole question of stoppages in production and of developing methods and machinery for the proper and judicial treatment of matters likely to lead up to disputes and for handling such disputes when they arose, would be a worthy outcome of an important conference such as that which was now being inaugurated.

He had now the pleasure of welcoming to the institution all members from the more distant parts of the country and the Dominions, and he hoped they would have an enjoyable and instructive time. The meeting was specially honoured that morning by the presence of the representatives of the United States and of Lord Bryce, who had contributed in no small degree to increasing and cementing the good feeling which existed between the United States of America and this country. He was quite sure that everyone present would join in extending to them a hearty and cordial welcome, not only to the institution, but to the country.

Dr. I. N. Hollis, President of the Worcester Technical Institution, said he took a profound satisfaction in being permitted to join his friends from home on a visit to London for the purpose of bringing to the Institution and to the engineers of Great Britain the best wishes of the American engineers, and to speak to them as fellow citizens of the same race. The present was a time of reconciliation and, it was hoped, of peace in the industries, for we have had enough of warfare and misunderstanding. Those present belonged to that profession which, from the earliest time, had through its inventions and its work in one form or another, laid the foundation on which civilisation had been built up. It had provided the tools and weapons by means of which cities had been built and States had grown into nations.

The members of the engineering profession stood side by side on the battle field and behind the lines as a support to those who were in the trenches, and American engineers took a pride in the greater share of their British colleagues towards victory in the cause of truth and justice. British engineers who braved the North Sea to keep the battleships and the destroyers fit for action stood between the insanity of power and their homes at a time when much that had been gained by centuries of pain and struggle seemed lost, and at a time too when the freedom of the world was in the gravest danger. American engineers gloried in the achievements of British engineers just as much as if they were their own. To those who died in the British service the American delegates paid their homage that day, confident in the hope that men would come to look upon them as a pledge that the men and women of their race would always be ready to give themselves to the cause for which those men surrendered their lives. They were members of the same race, for, after all, a race was created out of the same language and the same traditions.

All English-speaking people were working towards the fulfilment of the ideals of home, liberty and justice, born in these islands. His own country had been the human laboratory within which his forefathers and those of his hearers had taught to men of all nations the English common law and the English language.

The association of American and British people in the late war had brought them nearer together than ever for the hard tasks in the penumbra between war and peace, when none could see clearly. What were the chief tasks before them? They were concerned with the industrial welfare of their generation. The engineering professions had made the revolution of the nineteenth century. When James Watt tied the steam engine to a rotating shaft, he had created the problems of the twentieth century, problems that could be fully developed and solved only by the united efforts of all the engineers of the two countries.

There was one thought in his mind on the present occasion: the world needed the British and American people as citizens of a race that had dedicated itself to honourable dealing and justice. Whenever they had done wrong, there had always been some saving grace that had sent them back on their track to correct their faults.

It was Captain Josiah Tatnall, of the American Navy, who gave the immortal words: "Blood is thicker than water," and left his ship to go to the help of an English flagship. Few foreigners could understand the Selective Service Act that passed Congress in 1917. The Germans did not believe that it was possible for the Americans to raise an army, and he thought there were doubts in the minds of all Europeans. Yet America passed a law calling every young man between 18 and 35 to the Colours and to service in war, without disturbance of any kind and without organised opposition. Most of them came home with a profound admiration for the soldiers of the British Islands and Dominions. One of them wrote to him from the trenches: "I take off my hat to the British soldiers since I see what they have done in fighting and preparing at the same time." The moral he drew from that was that the American people had gone quietly into enormous preparation for war because of a real sympathy and friendship for the English cause against a destroying autocracy. The great issue of the twentieth century was the right of every man to earn a living and to develop his utmost possibilities physically and mentally, without being forced into a membership of some organisation and without being controlled by powerful combinations of any kind. It was the age-old struggle for individual rights under changed conditions. Industrial warfare was a disease needing doctors rather than courts and policemen. Men must be led, not driven to work. Nature had provided the motive and society existed to guide it.

Abraham Lincoln's definition of democracy as "government of the people by the people and for the people" was the best expression of political equality that existed to-day, but it was not the dominating note in most countries where that political equality had already been attained. The problem now was equality of conditions, the same comfort for all, not the differences of classes wherein some were in poverty and others in wealth and leisure. That did not mean communism or radical socialism, nor did it mean the surrender of property honestly gained by frugality and hard work. It was not a crime to be rich any more than it was a virtue to be poor, but a more equal division of the rough work of the world must be obtained. No one family and no line of families should find the door of opportunity shut. That problem must be solved, and it could be solved without drifting into the insanity called Bolshevism.

That was to a large extent the engineer's job. Technically the engineer had achieved pre-eminence in invention and construction; socially he had permitted others to exploit his work in creating a wider gap between rich and poor. Technically he was the creator of the nineteenth and twentieth centuries; socially and politically he took little share in directing the readjustments that must flow out of his creation. Technically he had founded educational associations for his own benefit; socially he had not employed them to promote the civic usefulness of his profession.

The American engineering societies amounted to nothing more then educational meetings for discussions of engineering papers a few years ago. They treated themselves, as an eminent American once said to him, as men educated and trained to occupy routine, subordinate positions, and the worst of it was that they accepted that definition. American engineers were now so conscious of the necessity of climbing out of a rut that they had organised in a larger way. Almost all the engineering societies scattered through the States to repre-

sent local and national interests had combined under what was called the Federated American Engineering Societies.

Co-operation in America began in 1902, when the friends of John Fritz subscribed money for a medal in his memory. The next step towards unifying the efforts of the engineers for public service, perhaps not chronologically but certainly most potently, was a gift for the Engineering Foundation, a board appointed to administer a fund for research without designation of the association under which the research was to be made, and without limit on the power of the board.

The great building in New York, given in 1906 by Andrew Carnegie to be the home of engineers, had at least introduced the American Societies to one another as societies. At first it was not entirely successful, but after years of thought and companionship they were all together under the same roof, as soldiers of peace who could work side by side. They were organised in very much the same way as the American Government, each separate group having its own local self-government, with a central organisation to speak for them all.

The executive committee of the Federated American Engineering Societies was called the American Engineering Council with power to initiate and undertake anything of interest to engineers and to the society. Each constituent part was just as free to carry on its work in its own way.

He repeated that to his fellow engineers in Great Britain because eventually they were going to have a larger association. He looked forward to the day not only when the American engineers would be more firmly drawn together but when all, Canadian, British, South African and American, would be banded together for the welfare of the world. They spoke the same language and did want to serve so that all men on this planet might feel that they could depend upon the engineering profession as the safe refuge in changing society.

The questions before engineers were :—(1) Peace in the industries, in transportation and in mining; (2) the training of men who laboured into a sound attitude of mind towards their specialities, so that they might obtain through them a satisfaction in life; (3) the elimination of unnecessary waste not only in the industries but in the houses as a means towards conserving civilisation; (4) the better occupation of leisure hours obtained through mechanical energy, so that outside of the time required to make a living men might obtain satisfaction through individual initiative in agreeable work; and (5) the prevention of war, the most wasteful of all agencies and perhaps, in the long run, the least beneficial for the development of nations.

A movement had begun in the United States through the efforts of the American Engineering Council to eliminate waste in industries. The subject was far larger, however, than the industries. It extended to every corner of national life and it was essentially the engineer's province. He brought it forward on the present occasion as part of the function of great societies like the Institution of Civil Engineers.

The elimination of waste was a real philosophy and it ought to be taught as such in the primary schools as well as in colleges. One of the important facts lost sight of in people's daily lives was that civilisation was promoted by leisure if that leisure was properly used. One invention after another had freed men from incessant hard labour. In America everyone liked to think of the present as the dawn of a new day for humanity, and if engineers could take up one other great issue that was before the entire world they could help to make it a brighter day. Should any country, large or small, be limited in its right to live in its own way by any league of nations or by any alliance of a group of nations? Never, so long as it did not interfere with the rights of others. War usually springs out of misunderstandings and the false ambitions of minorities. He was quite sure that Darwin would turn in his grave if he could but know how evolution had been twisted by the Teutonic mind into glorifying war as a developer of the race. Darwin never intended "the survival of the fittest" to have that kind of an interpretation, and furthermore he would have been shocked at the thought of any superman or super-nation. There could be no such thing and it was not true that the welfare of nations or the growth of civilisation was promoted by bloody contest on the battlefield. He might ask those present, as good citizens, how far the avoidance of war was possible, and every one of them would have a different answer. They could not differ, however, on the plain duty of the engineer to help with all his might towards the fair adjustment of every international difference. It was no reflection upon other nations to say that he believed the peace and welfare of the world was confided into the hands of the race to which the British and Americans belonged.

American Engineers' Message to British Engineers.

As evidence of the esteem the American engineers had for their British confrères, Dr. Hollis, in concluding, begged to present the following engrossed message to the engineers of Great Britain :—

"We, the Presidents of the four American National Societies of Civil, Mining, Mechanical and Electrical Engineers, on behalf of our Councils, send you our good wishes. We have instructed our representatives attending the Conference in London on June 29, 1921, to express our feeling of brotherhood and our deep sense of loss in the death of so many of our British colleagues on the battlefield. The soil beneath which they lie will always be sacred in the eyes of American engineers. We record here our sense of obligation to the naval engineers and constructors whose work enabled the British Navy to keep the sea as the first line of defence. We of America rejoice that we were permitted to share with the engineers of Belgium, France and Italy and with the men of our own blood the final victory over a war spirit dangerous alike to the rights and happiness of men. We glory in the memory of having stood by your side in battle, a guarantee to people of the British Dominions that the American Union will be always ready to give themselves in a like cause. With our greetings we pray that the engineers of all nations may dedicate themselves anew to justice and peace and to the service of humanity in a better and nobler fashion. We beg of you to accept this expression of esteem and goodwill as the voice of your colleagues and brothers of America."

The President said he accepted the address on behalf of the Institution of Civil Engineers with the very greatest pleasure and would take care that it was hung in a place of honour.

Dr. W. C. Unwin, who was asked by the president to reply on behalf of the British engineers, said he remembered that during four or five visits to the United States he had received much kindness from American engineers, and he was sure the members of the Institution had not forgotten the extraordinary hospitality with which a party from the Institution, under the conduct of Sir William White, were received by the engineers of that country. The delegation which had come with so gracious a message to the Conference were missionaries of kindness, and he could assure them that British engineers recognised the great advances which had been made in engineering science by the American engineers and immensely admired the remarkable constructive works which they had carried out in their great country. The heroism displayed by the American Army in the late war was as great as that displayed by any army in the field, and though he hesitated, when the loss of valiant lives had been so great, to speak much of the merely material aids supplied by the engineers in carrying on the war, after all, without ships, without guns, without munitions and without the inventions, the heroism of our armies would have been useless, and in that direction the United States had come to our assistance with their large manufacturing resources. The supplies of steel sent by the Americans were of immense value and not less valuable and essential were the remarkable machine tools for which the United States were so famous. We had been linked with the United States in the war, and he was sure they would not fail us in trying to establish peace and, as far as could be done, to make the recurrence of such a war impossible. What was chiefly required was better human relations, and the attendance of the American delegation to the Conference was one little indication that that feeling was spreading in the United States as well as here. There were various matters in which the British and American engineers were engaged, one being the great subject of the standardisation of engineering products, in which work the Americans were now doing quite as much as was being done in this country, and happily the two nations were working together. Also he was glad to see the great work which was being done in the United States in connection with engineering education.

Lord Bryce, on behalf of those present who were not engineers, heartily welcomed their friends from America, and entirely shared the sentiments which had been so happily expressed by Dr. Hollis. He laid stress on the international character of the engineering profession. He pointed out that seven or eight centuries ago learning was international and a learned man could make his home in any other part of the Christian world. It was very necessary to cultivate that international aspect of character which belonged to learning and to science. Men of science belonged to the world and worked for the world, and were welcomed by their colleagues wherever they went. That was especially true of those men of science who as engineers turned their science to practical account. The old alchemists endeavoured to turn lead into gold, but the modern engineer turned the raw crude metal of knowledge into the gold of action. He congratulated the members of the engineering profession on the enormous opportunities they had, and their successors would have, in making through the centuries that knowledge available for the profit and happiness of mankind.

Presentation of the John Fritz Medal.

The President next called upon Mr. Ambrose Swasey, the chairman of the Medal Award Board, to present the John Fritz Medal to Sir Robert Hadfield.

Mr. Ambrose Swasey said the delegation which was present had come as officers and members of the John Fritz Medal Board of Award, representing the four American national societies of civil, mining and metallurgical, mechanical and electrical engineers. The John Fritz gold medal was instituted by the professional associates and friends of John Fritz, that great American engineer, for his achievements in industrial science. The award was made annually for notable achievements in applied science. Previous awards had been made to men in Great Britain—to Lord Kelvin for his achievements in cable telegraphy and other scientific attainments, and to Sir William White for his notable achievements in naval architecture. A pleasing thing was the duty of the messengers to convey good wishes and tokens of high appreciation, and he felt especially gratified, as did the members of the delegation, that they were to-day bearers of the gold medal to be presented to another distinguished engineer of Great Britain, Sir Robert Hadfield, in recognition of his scientific attainments and his eminence in metallurgical research and for the distinguished service he had rendered in the invention and perfection of managnese steel. On behalf of the Board of Awards, he had the honour to present to Sir Robert Hadfield the John Fritz medal.

Sir Robert Hadfield, in acknowledging the medal, said he would indeed be wanting in appreciation if he did not say how deeply moved he was by the demonstration of goodwill shown by the great honour conferred upon him by the American engineering profession. From the bottom of his heart he thanked those present, Anglo-Saxons one and all, for the manner in which they had received the announcement of the bestowal of such a deeply prized honour upon him as a British engineer. He regarded it, however, as even much more than that, for in the official announcement he was told that the distinction should be accepted by him not only for himself personally but at the present time through him as an expression to the British nation, on the part of the engineers of the United States, of their high regard and appreciation of the work of the British engineer in the war for the preservation of civilisation. In the present difficult times that message, voicing as it did Anglo-Saxon comradeship and coming some three thousand miles over the great Atlantic ocean to brother engineers

in Great Britain and the British Empire generally, was indeed cheering and was a harbinger of good for the future of the race.

He thanked the deputation for their act of courtesy in coming to this country, when he ought to have gone to America, which, alas, had been quite impossible for him in the present times of industrial unrest. It would, he thought, be admitted by both American visitor and British host that that very inability was a blessing in disguise, as evidenced by the great gathering that day. He hoped the words of to-day might be translated into the actions of to-morrow, and that the good relations between the two nations would ever increase and so bear fruit in the world's advancement and true progress.

It was a great pleasure to have present the American friends, who were taking such a leading part in the ceremony, because it was in America that manganese steel first received its encouragement on a large practical scale. In addition, there was a singular appropriateness in the award being conferred before the Institution of Civil Engineers, inasmuch as the presentation of his original papers on April 28, 1888, giving an account of the invention of manganese steel, took place in the Lecture Hall of the old building of the Institution of Civil Engineers.

SECTION I.—RAILWAYS, ROADS, &c.

The section of the Conference devoted to railways, roads, bridges and tunnels met on Wednesday morning under the chairmanship of Mr. W. B. Worthington. The two subjects which were discussed were the "Structural Outlines of our Home Railways," and "Tunnel Maintenance." The notes introducing these, respectively by Mr. A. Ross and Mr. O. G. C. Drury, are reproduced in this issue on page 30. The discussion on the first subject was rather prolonged for the time available, and that on the second had consequently to be adjourned till Thursday morning.

STRUCTURAL OUTLINES OF OUR HOME RAILWAYS.

The discussion on this subject was opened by Sir Douglas Fox who said he was afraid that the most important matters to which the author had referred would have to be relegated to a considerable time hence, because they were impracticable without enormous expenditure. He did not think that there would be any difference of opinion as to their advantage. He had long felt the great importance of increasing the 6-ft. space to 7 ft. very much in the interests of the men employed. He did not think that enough consideration had been given to the men in regard to some of the points which had been mentioned. The same thing applied to the 11 ft. 6 in. between the main lines and the sidings. All those changes could be carried out to a considerable extent; but the great difficulty which would have to be faced was the difficulty of the tunnels and bridges. Between Dover and London there were, for instance, special obstacles in that direction, which could be removed only by very great expenditure. We could send our rolling-stock to the Continent, because, although the gauges were not mathematically the same, practically they were so; but continental rolling-stock could not be sent to us because of the width of our construction gauge.

Sir Vincent Raven said that as a mechanical engineer on railways, he would like to point out that it was of the first importance that there should be some standards for the structural parts of railways. Whatever was done in so large an undertaking must be done very gradually, but all would agree that it was of the very first importance.

So far as the 4 ft. 8½ in. gauge was concerned, from a mechanical engineering point of view he had not any great fault to find with it. Engineers would have been very pleased to have another 3 in. or 4 in., but at the same time it was possible to build to run on the present gauge an engine which would haul any loads which they could imagine would be taken over the lines for some considerable number of years ahead. If there had been a wider gauge it would have been possible to run these powerful engines at a much greater speed without the oscillation which there must be with the present narrow gauge.

So far as the 6 ft. way was concerned, he did not attach much importance to making it 7 ft. He would be perfectly satisfied with 6 ft. if it was in existence over all our railways. It seemed to him that if it were widened to 7 ft. the only advantage which the mechanical engineer would get would be that of building his rolling-stock somewhat wider than at present. Let them consider the case of the 6 ft., with 2 ft. 4 in. from the body of the carriage to the structure it was passing through, and 1 ft. 6 in. between the bodies of carriages passing on the two main lines, which experiments had shown to be sufficient; with these dimensions it would be possible to build the body of the carriage 9 ft. 8 in. wide. With this width, which was a great deal larger than any carriages built to-day—the widest being about 9 ft.—one could design for six passengers aside. He took it that any extra 6 in. or 8 in. in width would not give a railway an extra passenger, and after all, it was necessary to look upon these matters from an economical point of view. If there was not enough room for more passengers why should they go to the expense of another foot and some extra accommodation in the carriage simply for the convenience of the passenger? It would be necessary to carry an enormous amount of additional deadweight in order to provide that extra accommodation. That he did not think possible at the present time.

So far as the 11 ft. 6 in. between the two sets of running rails were concerned, he would suggest that 10 ft. were sufficient. When there were four lines of way, the two main lines should be in the centre, and the independents should be on the outside. If there were 10 ft. between the main lines and the independents, it should be sufficient.

He certainly agreed with having a good height for the structure. He should ask for 15 ft. in electric traction, which he fully believed in as the future means of transport on railways. He also advocated that the cornice of the structure should be as high as possible, because in designing an electric locomotive it was important to get a good wide cab and head-room for the driver. He also advocated a good distance between the locomotive and the outside structure, especially as near the rail as one could possibly go, to leave sufficient room for outside cylinders if powerful two-cylinder locomotives were to be built in the future. Of course, it was possible to get over that difficulty by building the engines with three cylinders, which he believed in as being better for the permanent way and better for starting purposes and balance.

He believed that the future of the electric locomotive was pretty well assured. When they got the electric locomotive they would be able to build a very high-powered machine to go in a much less structural space than would a steam locomotive. If engineers were given the outside limits which they would like in order to build such rolling-stock as was necessary for the heavy traffic of the future, it was necessary to standardise up the bridge structures. The mechanical engineer had gone rather ahead of the civil engineer in that direction. Girders should be strong enough to take a locomotive with at least 25 tons on one axle.

So far as the bringing of Continental traffic over here was concerned, to deal with the international coaches and wagons in this country would be out of the question so far as the cost was concerned. If they had to take that class of traffic, he did not think that it would be possible to arrange to bring it further than some gathering ground near London.

Mr. W. W. Grierson said that he was quite sure that every railway engineer and every railway traffic officer would agree as to the desirability of uniformity of loading gauge and clearance throughout the railway system. It was an object to be aimed at and ultimately obtained. But he did not know that he was altogether in agreement with some of the suggestions that had been made. Every increase in the width of the gauge meant an increase in the cost of structures and an increase in the capital cost of the undertaking. He was not of opinion that the substitution of 7 ft. for a 6-ft. way would be practicable. It would involve the destruction of a great number of bridges and tunnels, and not a few stations. It would involve enormous costs, and he was quite sure that the outlook of the ordinary shareholder would be a very poor one.

He agreed that 11 ft. 6 in. for the central space between four lines of way was desirable wherever signals or other apparatus had to be fixed; but he agreed with Sir Vincent Raven that elsewhere 10 ft. was sufficient.

The requirement that any structure over 2 ft. 6 in. in height should not be nearer the rails than 5 ft. would mean the destruction of all the centre girder bridges in the country, and, incidentally, it would not be possible to maintain the present platform height of 3 ft. He had noticed that near Paris on the suburban lines there were platforms which approximated in some cases to our present height. He thought that that indicated that where there were a large number of passengers to be dealt with, even abroad, the advantage of a higher platform was recognised.

As to electrification, he did not think that it ought to be overlooked that large portions of the railway system of this country passed through purely agricultural areas where the need for frequent trains was not likely to arise. In a country such as Switzerland where there was no coal and where, therefore, coal had to be imported at a high price, and where there was plenty of water so that electric power could be generated cheaply, the proposition was quite a different one. He thought that it was very probable that in Switzerland and countries like it, electrification would in course of time (probably not many years hence) become universal.

Mr. C. F. Bengough said he thought that perhaps it might be useful to look at the matter from the point of view of the North-Eastern Railway. There were no tunnels at all on the main line. There were three big stations—York, Darlington and Newcastle—at which the expense of widening the 6-ft. way would be very great indeed. In addition there were two swing bridges over the Ouse and there was the King Edward Bridge at Newcastle. It seemed to him that the expense of getting anything like a 7-ft. way on our railways to-day would be perfectly enormous.

Some members would remember that the question of using a 9-ft. wide wagon had lately been considered by a committee of engineers and by traffic superintendents. The conclusion come to was that this was quite impracticable on account of the difficulty there would be in sidings and alongside docks and warehouses and in private works.

Mr. Thomas Johnson said that there were two sentences or phrases in Mr. Ross's paper which he thought really were the key of the situation. The first was that changes must be effected for successful future working; the second was that such changes would vastly increase the capacity of the railways. Unless something could be done to increase the carrying capacity of British railways there was very small chance indeed of them paying in the future. He had seen and had been able to recognise the terrible limitations under which railways had to work in this country as regarded carrying loads. Very little had been said at the meeting about an increase in the carrying capacity of our goods rolling stock. On the North-Eastern Railway it would mean a tremendous saving in working expenses if they were able, in connection with their coal traffic, to work regularly wagons with a carrying capacity of at least 40 tons. In the United States they were now actually building wagons with a capacity of 80 tons. Railways in this country to-day were hauling about wagons of comparatively small capacity with a tare of something like one-half the carrying capacity of the wagon.

Mr. Grierson had said that if money were to be spent in alterations there would be nothing for the ordinary shareholders. He (Mr. Johnson) had come to the conclusion that there was not likely to be very much as it was. If ever an improvement was to be made in this country, a commencement had to be made. He spent nearly the whole of last year in China where with very great wisdom they were endeavouring to standardise at the outset of their railway construction. They had already adopted limits which were his envy last year when he compared them with the limits at home. China was now building as a standard wagon a wagon of 40 tons capacity. He did not think that any wagons having a smaller capacity would be built in the future. For carrying goods wagons of high capacity were

used, and of course locomotives were being built to haul them so as to have the very biggest paying load it was possible to haul. Those were all indications that other countries concerned with regard to railway working were recognising the need for attention to that point.

Sir Douglas Fox added the fact that very large wagons were employed for long lines and that the difficulty in this country was that the lines were as a rule very short had been lost sight of. It made a great difference in the size of the wagon whether the material had to be carried a long distance inland to the port or whether the goods, in very small samples, had to be delivered at various stations. For coal purposes a large wagon might be used in Great Britain, but he thought the great distinction between the United States system and the British system had been lost sight of, namely, the question of long distances.

Sir Vincent Raven added to his previous remarks that the North-Eastern Railway had not been behind in realising the value of large wagons. They had built 40-ton wagons some 20 years ago. The difficulty was, of course, to find a colliery which would be able to deal with that class of wagon under the screens and so forth. There was a colliery at Ashington in Northumberland which had a line directly to the coast; it was a colliery dealing with about a million tons of coal yearly and the railway took all that coal in 40-ton wagons. On the North-Eastern also 20-ton wagons had been adopted which he thought was unique as far as British railways were concerned. The proposition was quite a different one in a new country that was developing. There they could do things which an old country like England could not do. The railways in this country had to consider the traders to a very large extent.

Mr. C. J. Brown thought that Mr. Ross, since he gave up his connection with railways, was beginning to idealise a little bit as far as the railway with which he was concerned, because he was setting up a goal that would be found very difficult to reach. With regard to the wagon question, the Great Northern had been experimenting and were now running 50-ton wagons with a tare of only a little over 17 tons. The limitations on the extension of the use of those wagons was very great, chiefly on account of the facilities that were given by traders. It was one thing to build a heavy locomotive and another to build bridges which were to last forty or fifty years, and to look ahead and to see what the conditions were going to be at that time. Engineers were now moving, he thought, on the lines Sir Vincent had indicated.

The Chairman said the paper had brought out an expression of a number of the difficulties with which railway engineers had been struggling over a great many years. In the course of his life he had transferred his services from one railway to another and then to a third, and on one of those transfers he became aware of the nuisance of his new railway—that it had not the same loading gauge as the one he had left. There was only 7 in. difference in the haunches of the arch and it was the same height at the top. He set himself to work to make that railway able to take his big neighbours' loading gauge, but it took a good many years and a great many thousands of pounds to clear that 7 in. He mentioned that to show that little things run into large quantities of money when one began to touch the loading gauge. It was all very well to say that a beginning must be made, but to make a beginning in a country which was not commencing the railway era—in a country which made a beginning 100 years ago—was a very much heavier business. He believed there was an atmosphere now in which it would be possible to promote the standardisation and improvement of standards to an extent which had not obtained in the past.

Mr. A. Ross, in reply, said that he had said that the great blot on our railway system was the limit of capacity placed on our loading gauge, mainly the result of unorganised independent action and the absence of co-ordination among the companies—thereby meaning that some organised action should be taken. It was a matter for co-ordination and organisation and authority—above all for authority, so that whatever was done one railway could not go outside another railway. What he was really aiming at was that authority, a committee or whatever it was, should lay down an ideal to be worked to—not necessarily the figures he had put forward—and that every move in the future should be towards that ideal. What he had said in the paper was that railway lines should be classified, No. 1 class embracing the main trunk lines. He did not propose to take every railway in the country and make any drastic improvement at great cost, a great cost even if done gradually.

TUNNEL MAINTENANCE.

The second paper on "Tunnel Maintenance" was then read by Mr. O. G. C. Drury. This, as already stated, is reproduced on page 30.

The first speaker in the discussion was Mr. G. Elson, who said the value of the notes in the paper would probably be increased by comparison with the experience on other railways. On the railway with which he was connected there were 28 miles of tunnels, which passed through various strata, consisting of chalk, sand, gravel and different kinds of clay. There was one of 2¼ miles length which was constructed in the year 1800 and originally formed part of a canal. The dates of construction of the other tunnels was from the year 1840 onwards. The forms of the tunnels varied considerably; some few were inverted, others had no side walls, and the lining consisted of brick work in all cases. The bulk of the cost of maintenance had been due to the use of unsuitable brick, such materials having been used as had not been able to stand the pressures and the atmospheric influences to which they had been subjected.

Another cause of trouble, mentioned by Mr. Drury, was that the timber bars used during construction had been left in and subsequently decayed and had allowed the pressure to come on the tunnels. In every instance where the tunnel was constructed in a satisfactory manner with good materials there had been no trouble and the cost of maintenance in such cases had been very small.

The nature of the repairs carried out had consisted chiefly of cutting out the line where bulging had taken place or excessive deterioration of the brick work base had ensued and rebuilding with fresh materials. New inverts had been added, and in one or two cases where the arch was sprung from a strata the strata had settled owing to the pressure and it had been necessary to build new side walls. Repairs had been carried out wherever possible without interfering with the running of the traffic, but it had been found necessary to resort to single-line working in a number of cases, and in one case the main line had temporarily to be closed. That was the only case where the brick-work was actually crushed down.

When heavy repairs were carried out the cost was correspondingly heavy. In the eleven years from 1902 to 1912 he found that the cost of the heavy repairs on a length of 8 miles of tunnels amounted to 113,000*l.*, which worked out to about 15*s.* 9*d.* per lineal yard of tunnel per year. On the remaining 20 miles of tunnels the cost was very much less, only 9*d.* per lineal yard of tunnel per year. It had been found that ordinary bricks laid in Portland cement mortar of a strength of about 5 to 1 was the best material for lining tunnels. Neither galt nor stock bricks had proved satisfactory, both perishing in course of time. With regard to the use of the cement gun, it seemed to him it should be employed with great care. He had found that it was essential to remove the deteriorated face of the old brick work entirely before doing any repair work extending to a ring of brick work in thickness, generally two rings, and sometimes even more than that. Unless a tunnel was caught in its very early stages of deterioration the preliminary sand blast used with the gun was not going entirely to remove the bad work and the consequence would be cement rendering on unsound work. There was also the point which would arise, especially in damp tunnels where it was found that there were great variations of temperature, that the frost might quite easily get behind the cement rendered face with detrimental results.

The discussion was at this point adjourned to the following morning and we shall deal with it further next week.

SECTIONS II AND V.—HARBOURS, DOCKS, RIVERS AND CANALS AND SHIPBUILDING.

The two sections above-mentioned met together in the Great Hall for the joint discussion of three notes dealing with the dimensions to which docks should be constructed to provide for future requirements, ships and harbour design and equipments as affecting the rapid loading and discharge of cargo vessels, and the development of craneage facilities for discharging vessels of the largest size. The chair was first occupied by Sir Maurice Fitzmaurice, C.M.G., Chairman of Section II., and afterwards by Engineer-Vice-Admiral Sir Henry J. Oram, K.C.B., Chairman of Section V. The former, after a few introductory remarks explaining the work of Section II, mentioned that he had recently visited and examined a number of harbours in different parts of the world, and had found that the questions to be considered by the section were the same as had been discussed with him. On his return he had asked the Colonial Office to call a meeting of shipping companies trading through Suez in order to ascertain what provision should be made for the next ten or twenty years at ports in the East. He did not, however, propose to give the results of the meeting, as they would probably be mentioned by some speaker in the present Conference, but he stated that Colombo was the port especially referred to.

With regard to the provision of wharf cranes, which was dealt with in one of the papers, it might be of interest to state that he had found no cranes unloading ships in Montreal, Vancouver, Yokohama, Kobe, Manilla, Singapore and, of course, at Colombo, because there were no wharves at the latter port. At Hong Kong one or two cranes were in use. He mentioned that to show the necessity for a full discussion of the question of craneage facilities on wharves, in view of the fact that many steamers were now provided with derricks to lift loads of 30 tons or 40 tons on to the quays. The question with respect to that particular line of ports seemed to be whether the ships provided that equipment because there were no cranes on wharves, or whether there were no cranes on wharves because they were not wanted by reason of the ships' equipment. To that question he had not found an answer, and he hoped it would be dealt with in the course of the discussion.

They were also to have papers on reinforced concrete, a material which he had used in large quantities. There was still some anxiety in Canada when he was there in connection with the two years' investigation of all the reinforced concrete structures in the United States, Canada, Cuba and Panama, the results of which were published in 1917. The information given was the result of conclusions arrived at by sending a Questionnaire to all the different ports and also by personal inspections. It was only necessary for him to refer to one paragraph in their Report which stated that the majority of all reinforced concrete marine structures on the American coast subject to seawater action were now showing evidences of deterioration or failure, due to the corrosion of the reinforcement. The Report also stated that the structures examined were in no case more than 10 years old. Such a statement was, of course, very disquieting, unless they knew something about the design and construction of the structures, and whether the cement and the other materials were satisfactory. It was also necessary to know whether in certain parts there was ice action, or very great heat, which certainly had some effect on that class of concrete.

SHIPS' DIMENSIONS AND HARBOUR AND DOCK FACILITIES.

The three notes on the subjects above mentioned were then read by their respective authors in the order given, the first being by Mr. C. R. S. Kirkpatrick, the second by Mr. A. R. T. Woods, and the third by Mr. H. J. Deane. They were afterwards discussed together, and as all three are reprinted elsewhere in this issue (page 31) we may at once proceed to deal with the discussion.

Mr. F. E. Wentworth-Sheilds, who spoke first on the invitation of the chairman, said that Mr. Kirkpatrick's paper introduced the fascinating topic of what was to be the size of the vessels of the

future; they were all most anxious to know that. He gathered from the paper that the big vessel would come very rapidly but for the fact that port authorities did not provide accommodation for them. If, however, the history of negotiations between shipping companies and port authorities was examined it would be found that the shipping companies were not very anxious to pay for the expensive accommodation that had to be provided. Dock and port engineers knew very well that increasing the depth of a dock increased the cost of the quay per lineal foot in more than the simple ratio of the two depths. As ships become larger and depth of water and wharves had to be increased, the expense was multiplied by the square or perhaps the cube of the depth. As Mr. Kirkpatrick pointed out, all the other facilities, such as graving docks and approach channels, had to be correspondingly enlarged, so that charging a ship on a simple tonnage basis did not pay. If the small ship was charged on that basis it paid its expenses, but the same was not true of the large ship. That, he thought, was a serious deterrent in the matter of providing accommodation for very big ships. The point was well illustrated in Mr. Deane's paper, which showed that as the size of the ship increased the cargo density, *i.e.*, the amount of cargo in the ship per foot run of the ship, and, therefore, per foot run of the quay, rose very heavily in proportion.

Mr. Wood, in his paper, very wisely suggested that a ship's own appliance ought to be supplemented by quay-cranes. It was important to remember that there were many circumstances in which both worked together. He had seen the ship's winch and the quay-cranes pulling cargo out of the same hatch, but that required very good organisation. In the case referred to there were electrically-driven trucks to carry the cargo away as fast as it was brought out. If conveyors were used it was important that they should be portable, because it so often happened with mixed cargoes that the conveyor could be used for a few hours, and it was then necessary to employ the crane to deal with cargo for which the conveyor was quite unsuited.

There was much food for thought in Mr. Deane's paper. The author appeared to suggest that big passenger vessels ought to be made to find their own cranes. The speaker's experience at Southampton was, however, that the big passenger vessel needed the big crane more than any other class. In coaling a big vessel it was necessary to bring the coal barges up to both sides, and the ship had to be hauled clear of the quay to allow of this. It was impossible to design a ship's winch or crane which would reach the quay during the time she was hauled off, and in those circumstances it seemed to be necessary to provide not only a quay crane, but one of exceptional radius.

Mr. M. F. G. Wilson, the next speaker, said that he had listened with great interest to the papers, especially the first, with regard to the dimensions of ships. That question always troubled dock engineers, and one of the first things they asked a shipping company was: "What size vessels are you going to send, and are you going to increase the dimensions or not?" The usual reply was that they were going to increase the dimensions, and the question then arose whether heavy expenditure should be incurred in increasing the depth of the quays, in order to accommodate the prospective vessels. It was a question which would only work itself out very gradually, as it was very doubtful whether vessels would increase immediately to a large size. The length and breadth of a vessel could not be increased without increasing the depth, and that was where the difficulty of the dock engineer came in. The expense, the speaker pointed out, was increased not only by the reconstruction of the quay walls, but by the dredging and the maintenance of the channels. Beyond a certain depth most channels were muddy, and it was most expensive to dredge to a very great depth.

With regard to the question of large ships, Sir William White pointed out some years ago that unless these very large ships were kept fully occupied they would not pay for themselves, and it must be remembered that expenses and interest had to be met, even while they were lying alongside the quay. Then, again, there were not many ports to which very large vessels could run, owing to the want of deep water. The question of cranes raised another interesting point. As the chairman had pointed out there were very many ports and harbours which had no cranes at all, and yet ships got on very well there. Many ports at home and on the Continent had very large cranes, but there were many others which had none at all, and yet one never heard of ships being in difficulties in unloading their cargoes at those ports.

Mr. Deane had raised the question of the electric crane against the hydraulic crane. He himself liked the look of the hydraulic crane, and the quiet way in which it worked. Moreover, as Mr. Deane had pointed out, hydraulic cranes were quicker in action than electric cranes. There was no doubt, however, that the electric crane was displacing the hydraulic crane everywhere, and a new installation of hydraulic cranes was seldom seen. There was not very much difference in the first cost of the crane itself, but the cost of laying the hydraulic pipes, accumulators, and so on, added very largely to the expense of the hydraulic crane in comparison with the electric crane, which was much more flexible.

With regard to the reference in Mr. Woods' paper to the dockisation of the Thames, the speaker said he thought that would be a very dangerous experiment, although it had been mooted several times. The questions of the drainage of London and other places, and the silting which would follow the construction of the barrage, would make one think many times before undertaking the work.

The discussion was continued by Mr. C. R. S. Kirkpatrick, who said he would like to make one or two remarks with reference to Mr. Woods' paper and Mr. Deane's paper. He was astounded to hear Mr. Woods propound a scheme at the present time which had been dead for 130 years, viz., the dockisation of the Thames. In 1799 the suggestion was examined by a Royal Commission, but fortunately was not accepted, otherwise London would have been a derelict port of the same order of importance as Lynmouth and Lynton or some such place. The proposition, at that time, was to construct dams across the river near the Isle of Dogs, and two or three schemes were got out. Later on, somewhere about 1880, it was proposed to erect a barrage at Gravesend, but the scheme fell through. London had been practically made by its tidal river, with its free flow of water, but the suggested barrages would stop all that, thus making the river a dead and stagnant stream. There was also the problem of the drainage to be considered, and various other things. He felt very strongly upon the point, and was rather sorry that something so very dead had been resurrected. Mr. A. R. T. Woods here remarked that he was very glad that he had brought out some information on the subject.

Mr. Kirkpatrick, continuing, said that the question of cranage facilities was one which deeply interested Dock and Harbour Engineers. It was well-known that the advantage of the electric crane over the hydraulic crane, was that, in the former, the power consumed was proportional to the load, whereas the hydraulic crane required the same amount of water whether working with a full load or a light load. He had studied the problem a good deal, because of the demand on the part of shipowners for an increase in radius. On this point, however, the speaker pointed out that the load had to travel round probably half of the circumference, and consequently, as the radius of the crane was increased, the rate of discharging cargo became slower. He was trying to solve the problem by means of a new type of crane, but whether it would be successful or not, could only be proved by actual demonstration. His idea was instead of travelling the load on a radius of 60 ft., which on a semi-circle would mean about 180 ft. round, to employ a horizontal beam which travelled with a small monkey crane on the top. The load thus moved in a radius of about 30 ft., and also horizontally backwards and forwards along a straight line. As a result he hoped to have the advantage of the big out-reach, and to speed up the time of slewing by something like 25 per cent.

The next speaker, Mr. John R. Freeman, said that the mention of the dockisation of the Thames reminded him that for more than forty years they had a similar problem in connection with the City of Boston. He happened to be selected to study the matter thoroughly on behalf of the State of Massachusetts, and had arrived at the conclusion that many of the objections which had been made to the building of the Charles River dam were not well founded. The dam was built, and he would venture to prophesy that the time would come when a barrage would be built, perhaps not at Gravesend, but at some point down the Thames. One thing which emerged from the forty years' discussion was that the effect of the tidal scour in preventing silting had been greatly over-estimated; as a result of their operations the area of Boston Harbour was greatly increased. In conclusion, he ventured to prophesy that when the problem had been fully studied it was possible that, within forty years, there would be a Thames barrage.

Mr. C. S. Meik, who was heard with difficulty, emphatically supported all that Mr. Kirkpatrick had said about the dockisation of the Thames. There was, he said, no question whatever about the effect of such a work on the river. One had only to look at different places in the country where reclamations had been made to see how the channels had silted up. It stood to reason that wherever tidal water was taken away the scour was affected. With respect to the problem presented by the building of large ships, only two or three ports in the country were really affected. It was perfectly impossible for the majority of the ports, especially the smaller ones, to spend money in providing accommodation for such ships, because the return would not be commensurate with the outlay. In his view, the real solution was to build an entirely new port in a favourable position, and provide the necessary equipment.

Sir Archibald Denny, Bart., speaking on the subject of the future size of ships, said he agreed with Mr. Meik. Mr. Foster-King's table, which was quoted by Mr. Deane, predicted that passenger vessels would attain a length of 650 ft. in 1920. These figures had reference, of course, to the bulk of passenger vessels; not to leviathans like the Mauretania, the Aquitania and so on. Mr. King's prediction had come true. Cargo vessels had reached a length of 455 ft.; that was, pure cargo vessels, not mixed passenger and cargo ships. With regard to cranes on shore and on ships, Mr. Meik was quite right that only one or two ports had a large cranage equipment. The Chairman had mentioned many important ports where no cranage facilities existed, and the ships, therefore, had to provide their own. Indeed, if there was only one important port which had no cranes it would be necessary for ships using the port to carry them; it would, of course, be more economical to use ports provided with cranes than to have ships carrying cargo which could not be unloaded.

Mr. H. J. Deane, who followed, said he would like to defer his reply in respect of his own paper until the end of the session, but would make one or two remarks on subjects not connected with it. First, in connection with the suggested Thames barrage, he would link the designing of docks. In his view, the whole question of locks and docks lay between the proportion of the berths allotted to each lock and the amount of time in which each ship could be turned round. For instance, if it was reckoned that each ship would be turned round in seven days, and that 10 ships could be passed in and out through the lock each day, 70 berths would be necessary for each lock entrance. He thought it would be agreed that that was a most desirable provision. If there were less than 70 berths the lock entrance would be out of proportion to the size of the dock. While if the proportion of berths to locks was increased, one would be unable to deal with the traffic at the lock entrance. He thought the Thames barrage was impossible from that point of view alone. With the latest position assigned to the Thames barrage—somewhere near Gravesend—there would be some 60 miles of water frontage on each side of the river above the barrage, and it was difficult to see how to design a barrage with sufficient locks to accommodate all the shipping that ought to be using the Thames in the future. Once having dammed the course of the river at Gravesend, no

future development of turning ships round would be possible. The essence of the whole thing was to proportion the quay space to the locks.

With regard to future developments, the figures given by Dr. Corthell were probably the most suitable for the immediate future. It was impossible to legislate for 50 years ahead, and it would be undesirable to do so, because undertakings would be saddled with enormous costs which present-day shipping would be unable to meet. Docks and dock-entrances ought to be designed so as to be easily added to or deepened when the necessity arose, rather than planned to forestall the requirements of 20 or 30 years hence. The right thing to do was to legislate for the immediate future, 10 or 20 years hence, and let the rest of the demands look after themselves. In designing docks regard should be had to the traders who would use the port. It was obvious that a place like Liverpool was designed essentially to deal with vessels coming rapidly from America. The enlargement of passenger liners would have to be dealt with at Liverpool, or at some port on that coast. It was inconceivable that those large liners would eventually go to the Tyne —he would not mention London. If a port was designed to deal with cargo vessels and the average class of passenger steamers the question arose as to what the average would be.

Sir Westcott S. Abell, K.B.E., said there were three phases to the question of the size of docks. First, the large passenger ships of which there were about eight in the country. Secondly, the class of ships carrying a large amount of cargo and a small number of passengers, which might be called intermediate liners or cargo liners. That class passed gradually into another, which carried nothing but cargo; then there was the tramp steamer. It was possible to assign a general size to each of those three groups. For economic reasons it would not pay to work a bigger ship than about 8,000 tons deadweight as an ordinary tramp steamer. In reference to the big passenger liners, the war and the increased cost of everything had put back the provision of passenger facilities possibly for a generation, and it was not very likely that vessels would exceed 800 ft. in length for 10 years or so. In fact, he thought the tendency would be to make them shorter, broader and deeper. In the intermediate type, vessels of the order of 550 ft. in length, perhaps 600 ft. would be built so as to carry more cargo than they did at present, as well as a good many passengers. Roughly speaking, the limits of length in the three classes he had mentioned were 800 ft., 600 ft. and 450 ft. In assessing the trade of a particular port the number of tramp steamers, intermediate liners and passenger liners using it must be reckoned. Docking accommodation for large ships, he thought, might be provided by building one floating dock, which could be stationed somewhere in the United Kingdom and taken from place to place as occasion demanded. If it were capable of lifting 70,000 or 80,000 tons it could be used for all the big ships of the British Mercantile Marine. One such dock would be sufficient to serve all practical purposes so that the expense of providing graving docks, slipways, runways, and so on would be avoided. It would be necessary for the dock to be capable of dealing with ships of a draught of 45 ft.

The next speaker, Mr. A. T. Walmisley, referred first to the suggested Thames barrage scheme, which he regarded as quite ridiculous. A good deal had been said as to whether cranes ought to be carried on vessels or put on quays. The speaker, however, favoured the latter course, since as long as they were able to reach the desired position on a ship, a greater command of trucks and rails on the quay was obtained by having the centre of the crane on the quay than would be the case if it were mounted on the vessel. With regard to the question of the length of vessels, great attention had been paid to width and depth as well. It became necessary to widen the entrance of a dock, as well as the dock itself, at Dover, in order to admit larger vessels. It was intended to widen it to 68 ft., and after the work had been started they were informed by the Belgians that their Ostend vessels were of 72 ft. beam. The entrance could equally well have been widened to 75 ft., but as the work was in hand it had been finished at 70 ft.

With reference to the depth of vessels, the Royal Commission recommended 7 fathoms. There were not many docks in the southern ports of the kingdom with a depth of 7 fathoms. For instance, at Dover lately a vessel carrying 7,000 tons of American coal anchored close to the head of the Admiralty Pier, which had been extended by the Government to give a depth of 40 ft. at low water. Prior to that, a large collier drawing 23 ft. and upwards could not anchor at any place nearer to Dover than Chatham.

The last speaker in the morning session, Mr. H. Cartwright Reid, C.B., said that, as a dock engineer, he had been hopeful of hearing something definite from the shipbuilders as to the dimensions of ships in the future. One speaker, however, had given dimensions which were so strikingly different from those in Mr. Kirkpatrick's paper that it was necessary to pause before recommending dimensions for future locks so large as those proposed by Dr. Corthell. It was true that the cost of operating large vessels on the high seas diminished in proportion to the increase in size, but the cost of dredging the approach channels, of maintaining the entrances to locks, as well as that of the locks themselves, and of the wharf walls, increased in a very much higher proportion than directly as their depth. If dock engineers were asked to estimate for very large and very deep docks the financial officers of Harbour Boards would have to arrange the tariff to cover the extra cost. In a number of harbours the expense would be so great that if it had to be collected from the ships which had occasioned it, it would probably balance the economies effected in working a large ship. So far nothing very definite had been heard from the shipbuilders as to the possibility of 1,100 ft. cargo ships or 1,100-ft. ships of any kind, and in such circumstances the dock engineer would not be justified in recommending the large dimensions suggested by Dr. Corthell. At the conclusion of Mr. Reid's remarks the meeting was adjourned until the afternoon. We shall deal with its completion next week.

SECTION II.—HARBOUR DOCKS, BRIDGES AND TUNNELS.

On the conclusion of the joint discussion with Section V, Section B proceeded with the consideration of the papers down for discussion at the afternoon meeting.

Protecting Reinforced Concrete.

The best method of protecting reinforced concrete from marine deterioration formed the subject of an interesting paper read by Mr. F. E. Wentworth-Shields, O.B.E., M.Inst.C.E. Having emphasised the value of reinforced concrete to the harbour engineer, the author pointed out the liability of the material to deteriorate under the influence of sea-water owing to its softening the Portland cement through chemical action; to the scaling of the concrete through frost; to the erosive action of shingle, and to the splitting of the concrete owing to the rusting of the reinforcing steel. All these defects could, however, be largely overcome by selecting a suitable aggregate, by careful mixing and by permitting the concrete to harden in air before exposure to tidal action. In order to prevent cracking through the action of rust, as high a degree of impermeability as possible should be aimed at, and all steel should be covered by at least 2 inches of concrete. Overcrowding of the steel work should also be avoided, the working stresses kept low and the use of flat steel stirrups and links forbidden. In order to attain the desired degree of impermeability the author suggested that great care should be exercised in the grading and mixing of the concrete, particular attention being paid to the amount of water used, as either an excess or a deficiency of water tends to cause porosity. The employment of a rich mixture was probably the best method of rendering the concrete impermeable, 1 part of cement to 3½ parts of aggregate being recommended for harbour work. Covering the concrete with a thin coating of neat-cement grout and adding two coats of boiling tar had also been recommended as an effective means of preventing penetration of the sea-water to the concrete. In concluding his paper the author emphasised the need of some simple tests for the permeability of concrete, and the establishment of suitable standards in this respect.

Mr. G. FitzGibbon, M.Inst.C.E., in his paper dealing with reinforced concrete for wharves and breakwaters, also drew attention to the defects which had appeared in reinforced concrete structures exposed to tidal action, and ascribed these defects to faults in design and construction rather than to any inherent defect in the material itself. He pointed out the difficulty of under-water bracing in reinforced concrete, and suggested the possibility of casting a horizontal brace, having a length of cylinder at each end, and lowering it down over two pile clusters, or of even casting an entire panel of horizontal and diagonal bracing, with the necessary lengths of cylinder.

After referring briefly to the construction of the King's Dock, Swansea, and reinforced-concrete work recently executed in the Port of London, the author suggested for discussion the possible advantages of the caisson method of construction for deep-water wharves and breakwaters, and referred briefly to several modern instances in which this type of construction had been successfully adopted.

Deterioration of Reinforced Concrete.

In his paper, "Reasons for the Deterioration of Reinforced Concrete above Mean Tide Level," Mr. L. H. Savile, M.Inst.C.E., pointed out that in reinforced-concrete structures designed on the lines of the earlier timber structures that preceded them serious defects had in many cases made themselves apparent between high and low-water levels and even in the deck beams well above high water mark. Confining his remarks chiefly to the defects arising from rusting of the steel reinforcements, the author analysed the causes of oxidization, and the circumstances under which it occurred, and through such analysis indicated the steps which might be taken to prevent the rusting of the steel reinforcements.

The meeting concluded with a general discussion on the several papers read, in which a number of members took part, the views expressed being generally in accordance with those of the authors rather than of a critical nature. That the defects which had appeared in reinforced-concrete structures exposed to sea-water could be overcome, or at least mitigated, by improved design and better methods of construction was generally conceded, although opinion was divided as regards the lines upon which such improvements should be sought.

SECTION III.—MACHINERY.

Reciprocating Engines *versus* Turbines.

Section III met in the library, the chair being occupied by Captain H. Riall Sankey. In the first paper taken, Mr. Hugh Lupton instituted a "Comparison between reciprocating pumping engines and turbine-driven centrifugal pumps." We shall publish this paper in full in our next issue, and in the meantime may say that the author claimed that in water works service, to which his observations were confined, the reciprocator was more reliable and economical than its rival, but admitted that it cost more to install. As instancing the former qualities he stated that a triple-expansion pumping engine installed at Bristol in 1914 had been constantly at work since that date at a total cost for "outside" repairs of 50*l.* 12*s.* 6*d.* Tested when installed, its steam rate was 12·37 lb. per water horse-power, and when re-tested in January last the figure of 12·6 lb. was obtained. Again, a reciprocator erected at Milwaukee thirty years ago had recently been overhauled for the first time. It had worked in all 162,000 hours, and it turned out that the consequent wear in the high-pressure cylinder was about $\frac{1}{4}$ in., and somewhat less in the intermediate pressure and low-pressure cylinders. The best steam rate for a reciprocating pumping engine quoted by Mr. Lupton was 10·97 lb. per water horse-power hour, whilst the best test figure he had been able to obtain for a turbo-centrifugal set was 16·7-lb. per water horse-power hour. As regards capital costs, one of his estimates placed the cost of a turbo-centrifugal pump at about 1*l.* 13*s.* 4*d.* per water horse-power, the corresponding cost of a reciprocator being 5*l.* 12*s.* In the discussion, Mr. Barker objected that in this estimate the cost of foundations had been omitted. These, he said, would cost about 5,000*l.* for the turbine and 15,000*l.* for the reciprocator, making the comparative figures 2*l.* 8*s.* and 15*l.* 3*s.* 4*d.*, respectively. The author's

claim for a higher endurance for the reciprocator was disputed, but Mr. Maude, whilst stating that he knew of a case in which a turbo-centrifugal had run ten years without repairs or replacements, observed that, in view of the steadily increasing efficiency of steam turbines, it might well be economical to have a complete replacement at the end of fifteen years. For dealing with variable heads, he said that variable speed motors should be used, in which case there would be little variation in the efficiency with change of head.

USE OF EXHAUST STEAM.

The second paper to be discussed dealt with "Exhaust Steam: Its Employment for Power, Heating, &c.," and had as its author Mr. R. E. Dolby. We shall reprint this in a later issue. The main point raised was the large waste of heat now general whenever power is generated by steam. The author maintained that exhaust steam should be distributed for heating purposes through public mains. The almost universal loss of heat and consequent loss of fuel was admitted in the discussion, but serious doubts were expressed as to the practicability of utilising much of it. It was pointed out that in America where central heating by waste steam originated, the conditions were very different from what they were in this country. In the first place, the weather is much more severe, and in the second, the temperature at which rooms are kept in winter is 10 deg. F. higher. For both reasons the sale of heat per foot of main laid would be much higher than in this country. Here the cost of heating an eight-room house in this way would, it was stated, be of the order of 40*l.* per annum. Moreover, as one speaker pointed out, in our older towns and cities there is little or no space available to accommodate the 20-in. or 24-in. pipes which would be required, so that the best opportunity for installing such a system would be in new garden cities. Many instances were given of the large savings effected when waste heat could be utilised. It was stated by Mr. Weekes, when electricity was generated as a by-product to a heating plant the coal consumption per unit was less than ½ lb. and was little affected by the load factor. In most cases, however, there is a great difficulty, owing to vested interests, in finding a market for waste heat. If utilised in exhaust steam turbines, electrical undertakers will not in general take the energy generated on equitable terms.

A full report of this meeting will be given in our next issue.

SECTION IV.—MINING AND METALLURGICAL PROCESSES.

This section met in the Reading Room, and was presided by Sir Robert Hadfield, who in a lengthy address dealt with America's progress, the world's iron and steel requirements, &c. He laid stress upon the wastage of iron and steel by corrosion and called the attention of the meeting to the work by Sir John Dewrance on this subject. Sir Robert also referred to the cheap water-power energy available in large amounts in other countries, competitors of ours, and in face of this it behoved us to study very closely our own means of production. He referred also to various Scottish water-power schemes. Dealing with the work of former engineers and scientists, he paid a special tribute to that of Whitworth and instanced the difference which existed between the tools available in the time of Whitworth and those of the present day; the latter represented such a heavy capital expenditure that it was impossible from an economical standpoint to shorten their working time.

The first paper was by Mr J. W. Evans, F.R.S.; it reviewed the employment of water power in the development of the mineral industry in various countries, including our tropical Colonies and Protectorates where the reserves of water power were of special interest in connection with the occurrence of bauxite among other minerals; the water power could be used for extracting metallic aluminium from the bauxite on the spot, instead of simply refining the bauxite to obtain pure aluminium oxide and shipping this to Europe.

Mr. Morrison stated that the author, in referring to British Guiana, had not mentioned a waterfall there, up country, which was comparable to Niagara. In regard to the utilisation of energy from water power he would add to the author's list the electrolytic manufacture of pure iron, for which he believed there was a future, and the manufacture of magnesium where this could be produced at a relatively low cost. He referred to the Lochaber Power Scheme (described in our issue for May 20, page 622 of our last volume) and to other possible power schemes in Scotland.

Mr. Whitney said he had been engaged in the Bombay hydro-electric scheme, in a district where no river was available, but where they depended upon the storage of rainwater during the monsoon; they had now vast lakes storing this water which provided the electric energy required. He emphasised the great advantage to be derived by studying the rainfall.

Other speakers dealt with the impracticability of transferring to the Rand the energy derived from the Victoria Falls owing to the distance between the two; emphasised the services which the Cedar Rapids Company, and the Shawinigian Water Power Company, rendered during the war to the Canadian output of munitions; expressed the opinion that in this country the only economical way of utilising water was to do so in the shape of steam; called attention to the vast mineral resources available in the Himalayas; believed the film of oil to counteract evaporation in tropical countries could be replaced by the "water lettuce" which covered a large part of the water surface.

In the course of his brief reply, Mr. Evans thought it would be possible to treat the bauxite on the spot as suggested. He was sorry to hear the supply of energy to the Rand from the Victoria Falls had been abandoned. The mineral wealth of the Himalayas was not comparable to that of the Rockies or the Andes.

Mr. C. P. Sandberg then took the chair and Mr. R. Nelson read his paper on "Recent Developments in Coal-Cleaning Processes." This was illustrated by a demonstration of coal flotation by Professor Edser with a small apparatus. Colonel Rose emphasised the difficulty of drying coal economically.

Mr. Merz considered that the question from the point of view of the user was one of great importance, both in regard to actual cost and efficiency in consumption, and he hoped the collieries would now supply the consumers with the coal they wanted and not only with the material as it came direct from the pits. He questioned some of the author's figures. Mr. Foster referred to the Wilfley Falls; these could serve for coal, and with them 90 per cent. of free ash could be removed. These tables were used for ores, when the reject was the lighter material; used for coal after a small alteration, the lighter material would be the coal.

In the course of his reply, the author stated the flotation process dealt with fine coal. The drying difficulty was overcome by a vacuum dryer, but this was rather costly. He was glad consumers were not prepared to further receive the bad coal sent them since decontrol. In regard to the 82·45 per cent. of ash given for his reject, no process gave 100 per cent., and some of the reject had shale and a volatile matter content. Better results would probably be obtained by using more wash boxes.

The last paper dealt with the François cementation process, read by Mr. H. S. Ball. It explained the use of cement in filling up fissures and stopping leakages in various works, mainly underground.

Mr. Whitney stated that this method had been used by him to fill a fissure which had occurred in in the dam of a reservoir in India. A full report of this meeting will be given in our next issue.

SECTION VI.—WATERWORKS, SEWERAGE AND GASWORKS.

THE UTILISATION OF WASTE HEAT IN GASWORKS

At the meeting of this section at 11.30 a.m. on the 29th ult., Dr. C. C. Carpenter was in the chair. The first paper taken was one entitled "The Utilisation of Waste Heat in Gasworks," by Mr. G. E. Stewart. This covered an analysis of the various heat losses which normally took place in the processes carried out in a gasworks and which there had been a tendency to neglect in the past owing to the availability of cheap fuel. The new conditions which had arisen had, however, brought them into attention. Any energy available from recovered waste heat in a gasworks could be applied for power purposes in the works or for generating steam to effect the reaction in water-gas manufacture. For the former of these purposes coke or coke breeze was usually employed, but such material was now receiving appreciation from outside consumers. Mr. Stewart went on to analyse the losses involved in the various processes of carbonisation, water-gas manufacture, &c., and gave a large number of figures showing the waste heat available. This portion of his paper is not suitable for brief summary, and we will reprint it in full next week, with a full report of the discussion, which was opened by Mr. Goulden, who said that the subject had become of great importance since the introduction of vertical retorts. Until their introduction there was not much heat going to waste. Several of the speakers dealt with the subject of waste heat boilers, but we will reserve their remarks for publication later.

DESIDERATA IN THE QUALITIES OF TOWN'S GAS.

The second paper in this section was one carrying the above title, by Mr. J. S. G. Thomas. As with the first contribution, we will reproduce this paper and the discussion concerning it in full next week. For the moment we may say that Mr. Thomas pointed out that the expression "town's gas" had become a misnomer with the development of the industrial use of gas, and that even the word "gas" itself could not be considered entirely satisfactory, since town's gas now consisted of a mixture of some more permanent gases with unsaturated or saturated vapours of certain liquids and even solids. The complex nature of the gas itself and the diversity of manners of its application made the consideration of desiderata in its qualities a matter of some difficulty. The enactments of the Gas Regulation Bill by giving gas companies more latitude had somewhat simplified the problem. Mr. Thomas went on to say that a desirable condition was the elimination of sulphur, and recent work had established that reduction to a mere trace could be achieved industrially. Another point was that there seemed no physical justification for the inclusion of inert gases, since these were available in unlimited quantities at the point of consumption. At the present stage, however, it would not be desirable to place any legal restriction on the permissible percentage of inerts, and the consumer was protected by the "declared calorific value." A further point was that naphthalene and cyanogen should be eliminated as far as possible.

This closes our present report of Wednesday's proceedings. Fuller reports of the later meetings will be published in our next issue.

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

As we have already announced, the Institution of Mechanical Engineers is this week holding a conference at which a number of important engineering questions will be dealt with. This Conference was opened at 10.15 a.m. yesterday, only a short time before the present number of ENGINEERING has to be prepared for press, and it is therefore impossible to give an account of the proceedings in this issue. All we can do is to record briefly that at the opening meeting the President of the Institution, Captain H. Riall Sankey, delivered a cordial address of welcome to the delegation of American engineers now visiting this country and subsequently announced that Mr. Ambrose Swasey, the chairman of this delegation and an engineer whose work is widely known and appreciated here, had been elected an Honorary Life Member of the Institution of Mechanical Engineers. We shall, of course, deal fully with these proceedings in our next issue.

The Conference is being continued to-day, and we may add that in connection with it an exhibition is being held in the Hall of the Institution which is well worth a visit, the exhibits consisting chiefly of instruments and appliances more or less allied to the subjects discussed at the Conference.

MOTOR-WINCH WITH 7-HORSE-POWER PARAFFIN ENGINE.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

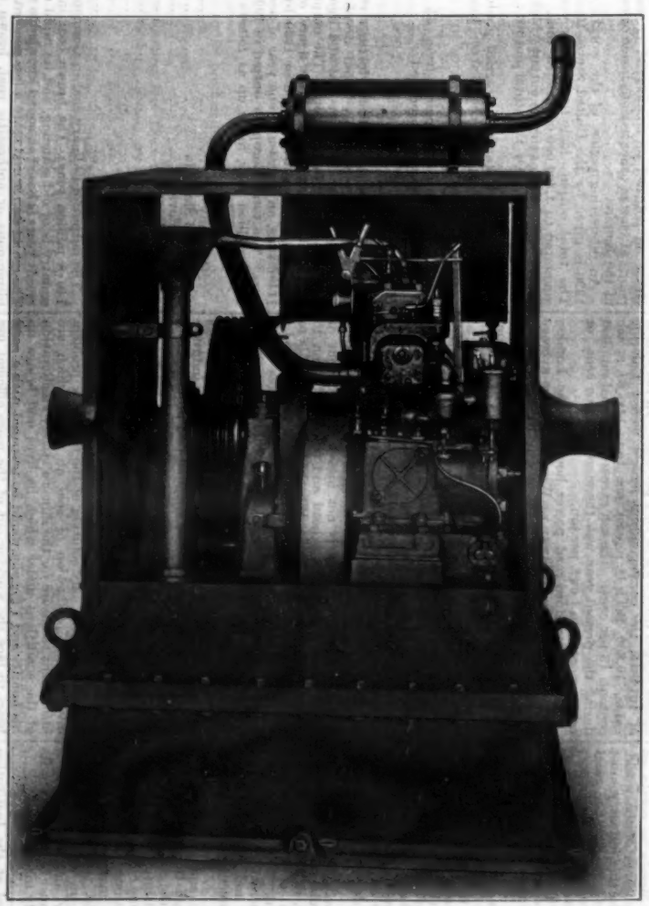


FIG. 1.

FIG. 2.

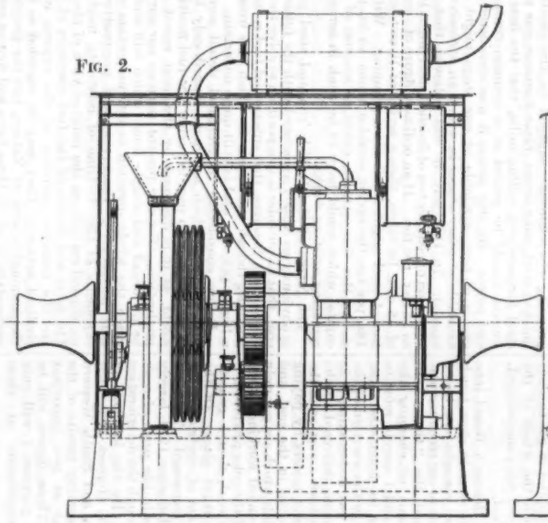
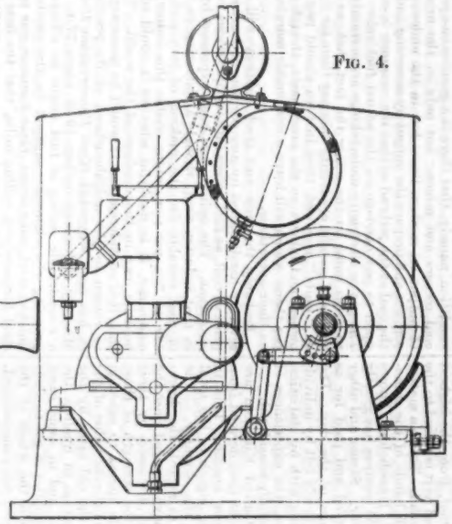


FIG. 4.



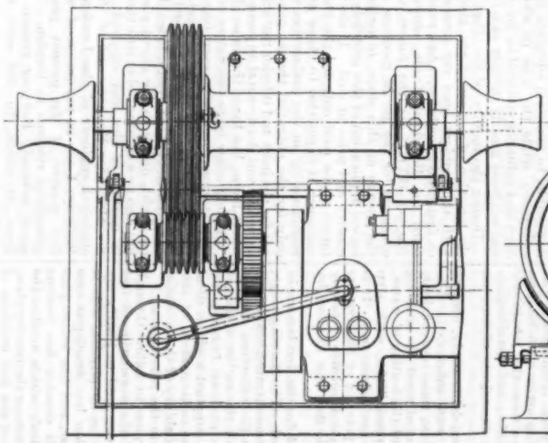


FIG. 3.

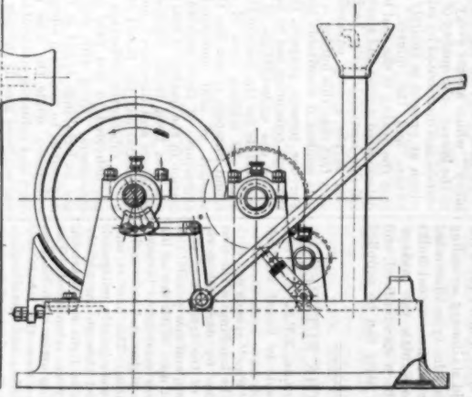


FIG. 5.

THE advantages of small motor winches for the cheap and rapid handling of ships' cargoes or of material generally, are well recognised, but the climatic and other conditions to which such machines are exposed demand a design in which the working parts shall be properly protected from injury. Simplicity and strength are also essential in view of the class of labour usually employed to operate winches. To meet the requirements of the owners of cargo craft and others who employ winches in exposed situations, the Parsons Motor Company, Limited, of Town Quay Works, Southampton, have brought out a new design of motor winch, the general arrangement of which will be understood from Figs. 1 to 5, above. The motive power is furnished by a single cylinder engine of 7 brake horse-power using ordinary paraffin as fuel, and embodying all the features which the long experience of the firm in the manufacture of oil engines has shown to be desirable. These comprise a complete system of positive pump lubrication, with gauges to enable its proper working to be seen, so that all filling up of lubricators, adjusting drips, &c., is eliminated. There is also an enclosed vertical governor which operates independently of the ordinary hand control.

The engine drives the back shaft by means of friction reducing-gear. This shaft carries a central drum, 6 in. diameter, holding 75 ft. of $\frac{3}{4}$ in. wire rope, which will lift a load of 5 cwt. at the rate of 200 ft. per minute. In addition to the winding drum, there is a warping head at each end of the shaft, the overall width over both warping heads being only 4 ft. 7 in. The width across the plant from front to back is 3 ft. 8 in., and the height to the top of the silencer is 5 ft. 3 in. The weight of the complete machine is 25 cwt. and eyebolts are provided as a means for convenient slinging. The self-contained nature of the plant is a noticeable feature. The fuel tank is inside the casing, and the cooling water is contained in a tank formed in the base plate, which is made specially deep for this purpose. A circulating pump on the engine draws the cooling water from the tank, delivers it through the cylinder jacket whence it passes back to the tank by means of an open funnel, in which the flow can be seen at any time.

The operation of the winch is controlled by means of

the hand lever on the left-hand side, which causes the load to be raised, lowered, or held stationary according to its position. Two winches of the type illustrated have recently been supplied for service on coal hulks at Falmouth, and in accordance with the makers' usual practice, the design has been standardised, and complete winches or component parts can be supplied from stock.

FUEL PROBLEMS OF THE FUTURE.*

By Sir GEORGE T. BEILBY, F.R.S.

CIVILISATION on its physical side is based on fuel. Of all the powers of Nature which have been turned to his use and convenience by man "Fire" stands out with a distinction which is unique. The kindling of the first fire of dried leaves and branches by our prehistoric ancestors marked the beginning of the transfer of this mighty power from the gods to man, and new possibilities of prodigious import were opened up. With fire at his command, a new dividing line was established between man and the lower animals, and a higher and more social standard of living became possible. The horrors and dangers of the darkness of night were greatly mitigated, while social instincts were aroused through the nightly gathering round this new source of light and warmth, and imagination and thought were stimulated. The charred stick supplied the budding artist with his first pencil, while the glowing embers were the laboratory furnace in which the coming chemists and metallurgists made their first observations on the effects of heat on rocks and stones.

Fire, first automatically and then deliberately, became the test to which all materials were submitted. The arts of the craftsman were based on these observations, the smelting of metals, the bending of wood, the singeing of skins, the melting of gums, and the boiling of water, started a whole train of new possibilities, each step in discovery opening the way to new adventures. It is no exaggeration to say that the practice of observation and experiment on which the physical science of to-day is founded, had its origin in the first fire kindled by man.

In the management of the wood fire the first lessons in the properties of fuel were learned. The flaming stage, followed by the steady and more concentrated heat of the glowing embers, naturally led to the collection of more massive embers by the control of the earlier stages of combustion, thus leading up to charcoal burning, by which the worker in metals was supplied with an ideal fuel for his operations. Thus the carbonisation of raw fuel as a means of raising the availability of the potential therms it contains, had its origin in the remote past.

It is far from our present purpose to follow through the ages the romantic history of the association of fuel with civilisation. Enough has been said to justify my opening remark that civilisation on its physical side is based on fuel. This inter-relation has developed new features during and since the war, and the future production and use of fuel in this country has become closely associated with social ideals which involve the raising of the standard of living among the mining class. This indeed is the most pressing of the fuel problems of the near future. Can coal again be produced at a price which will enable this country to take its place in the markets of the world, while the present standards of wages and working hours are maintained? Careful and impartial students of the economic facts of the situation tell us that this is not possible. Merely to regain an entrance into the iron and steel markets of the world, we are assured that the coal used in this industry must not cost more than 18*s.* to 20*s.* per ton. For the great transport services of the country a slightly higher cost for coal might be faced if all the available measures of economy in its use as fuel are adopted. It is obvious that, without a greatly increased output per man, the earnings of the miner cannot be maintained at their present figure.

This end can only be attained by a genuine co-operation between the coal owners and the miners; any half-heartedness on either side will in the long run lead to failure. How is such co-operation to be secured? The miners have pinned their faith to nationalisation as supplying the solution of the problem. The nationalisation the more extreme section have in view appears to involve the handing over the direction and control of the industry to nominees of their own, who would in effect be pledged to regard the interests of the wage-earners as paramount.

While the nation is in sympathy with the raising of the standard of living of the miners, and the improvement of working conditions in the mines, it has no belief that nationalisation would supply a commonsense and practical solution of the problem. The nation also realises that no system of bureaucratic control would adequately replace the individual and collective effort which is necessary for the development of this complicated industry.

The significance of the patience and self-sacrifice of the consumers of coal right through the difficult times which culminated in the strike of the past few months, appears to have been missed or misinterpreted by both miners and mine-owners, and to some extent also by the Government. This remarkable patience on the part of the whole British public does not mean that they are either ignorant of, or indifferent to, the future availability and cost to them of the fuel on which their daily lives must depend, both directly and indirectly. If a permanently higher cost of fuel must be faced, then its availability must be correspondingly increased,

To take only one aspect of this question of "availability" which affects every consumer, from the highest to the lowest—the quality of the coal as it is raised to the surface and distributed by rail and road. This is a matter which at present is entirely in the hands of the mine-owners and the miners. Every householder knows that the quality of the coal he or she receives has greatly deteriorated during and since the war. Stones and other inferior materials have been received and paid for as coal at the greatly enhanced prices of the day. The very fact that this burden is most widely felt by individuals renders it unsuitable for dealing with by statistics. For our present purpose, therefore, the experiences of the large consumers can be more usefully considered.

The gas undertakings of the United Kingdom are responsible for the distribution of the heat derived from about 20 million tons of coal per annum. This in round numbers is not less than one-eighth of the total amount of coal consumed in the country. The experiences of these undertakings as regards the depreciation in the quality of coal they have received since the war has been freely disclosed and discussed by their engineers and directors; and on the strength of these representations the Board of Trade agreed to sanction a very substantial reduction in the calorific value of the gas delivered to and paid for at the old rates by the consumers. Even with this relaxation in quality, the gas undertakings found it difficult and in some cases impossible, to maintain adequate supplies of gas to their consumers, while the coke in which the whole of the inert and valueless material in the coal was concentrated, was rendered greatly inferior as a fuel.

During the inquiry of the Fuel Research Board into the question of gas standards, they were in close touch with this subject, and my present remarks are based on first-hand knowledge. As a result of our recommendations the Board of Trade adopted the "therm" of 100,000 B.Th.U. as the future unit of charging the consumer for the gas he receives, and I merely refer to the change at this stage, in order to demonstrate the logical application of this principle to the question of the quality and price of coal. If the gas undertaking is in future to be paid only for the therms delivered to the customer, it is entitled to throw at least a portion of the responsibility on the coal-owners and miners by paying only for the potential therms received in the coal, and not for the inert and inferior materials which are not only valueless and detrimental to economical working in the retort-house, but lower the value of the coke produced.

Among other large consumers of coal, electric generating stations occupy a very important place. Of the total cost per unit in the generation of electricity, the larger proportion is due to the fuel consumed. This cost has been trebled, or even quadrupled since 1914, largely no doubt, owing to the direct rise in the price of coal, but also to a substantial extent through the deterioration in quality of the coal supplied. By the kindness of Sir Alexander Kennedy and of Mr. Herbert Jones, the electrical engineer of the London and South Western Railway, I am in possession of working results of the first quarter of the present year at two important generating stations in London. These figures will be again referred. For our present purpose I will only draw attention to the coal experiences at these stations.

In the case of the Central Electric Supply Company, the calorific value of the coal received for 13 weeks averaged 10,581 B.Th.U. Its cost per ton was 45*s.* 2*d.* and its ash content 18·4 per cent. The weekly ash figures ranged from 16·3 to 20·1 per cent. In the winter of 1914–15, the corresponding figures were: Calorific value, 10,800 B.Th.U.; cost per ton, 14*s.* 6*d.*; ash content, 13 per cent. The ash excess on the coal supplied during the present year was therefore 5·4 per cent. or rather more than 1 cwt. per ton.

At the Durnsford-road power house of the London and South Western Railway at Wimbledon, the average calorific value of the coal received was 10,900 B.Th.U., and the ash 16 per cent.

The undesirability of transporting inert material from the pits to the power station must be taken into account.

Examples of this kind could be multiplied indefinitely from the experiences of private firms and public institutions, but the foregoing are sufficient to establish my point, which is, that in view of the stage reached by the national coal problem, the time has come when the vital interests of the consumers must be reckoned with in any settlement which is arrived at. These interests require that the mine-owners and miners must alike realise that their responsibility is not met by the output of mere material at the pit head and its distribution to consumers by road or rail. Whether this material is to be consumed in its raw state as fuel, or whether it is to be converted into fuels of higher availability by gas works or other carbonising and gasifying agencies, what counts is its thermal value. To the miner it may seem a revolutionary proposal that he should be paid by the therms he sends to the surface; but as he himself possesses views in connection with the development of his industry involving a treatment of the national fuel problem from an entirely new and revolutionary point of view, he cannot logically ignore the effects on the consumer and on the nation at large of the permanently increased cost of fuel which must result if his claims for a higher standard of living are to be realised.

To my mind it would be a serious set-back to our civilisation if the only solution of the economic problem involves the production of coal at prices which are insufficient to ensure for the miner a steady amelioration of the conditions under which he lives and brings up his family, and I for one would be prepared with a good heart to face the working out of the more efficient use of fuel which is absolutely necessary if a higher price is to be paid for coal. This, however, would only be on one condition, namely, that there is a genuine co-operation of coal owners and miners, not only in the organisation of output on modern lines, but in the endeavour so to sort out and prepare the output by screening and washing the coal at the pithead so that the consumer is only called upon to pay carriage on the actual fuel value received. The gas or electricity undertakings are certainly entitled to press home to the miner the fact that, as the consumers of gas and electricity only pay them for "therms" or "units" received, they in turn should pay the coal owners and miners on the same basis, though at a cost per therm which will leave a reasonable margin of profit on their operations.

Probably the iron and steel industry will be most severely handicapped by any permanent increase in the price of coal, as fuel enters into its operations to so large an extent. The opinion has been expressed by experts in that industry that, though a reduction in the price of coal suitable for the making of iron and steel to 18*s.* to 20*s.* per ton, might enable this industry to recommence, it is doubtful whether it could ultimately hold its own in the markets of the world. To ensure this, it is considered that it would be necessary for coal to return to the neighbourhood of its pre-war price. It has been suggested (Coal Conservation Committee, Ministry of Reconstruction, 1918, pages 77 to 81) that a considerable saving of fuel might be effected by so grouping the elements engaged in the production of finished steel, coke ovens, blast furnaces, gas producers, steel furnaces and rolling mills, that the heat from all sources should be pooled at a common centre of heat and power. By this means it was considered that any excess of heat available at one stage might be made available at other stages in which an excessive demand existed. In this way it was believed that the consumption of coal per ton of finished steel might be reduced to 35 cwt. per ton. If an ordinary figure of consumption of 45 cwt. be taken, then a saving of 10 cwt. of coal per ton of steel might result from grouping. With coal at 18*s.* per ton the saving would amount to 9*s.* per ton of steel. But this estimate takes no account of the large capital which would have to be sunk in scrapping and replacing existing works.

The future of the British iron and steel production is obviously so closely associated with the future price of coal, that no outsider is in a position to solve the problem. We can say, however, that substantial fuel economies are possible, though the extent to which this would justify a higher price for coal is still quite uncertain.

Before considering in technical detail some of the fuel problems which are more immediately before us, it may be well to pass in review the fuel position of the world, as it is disclosed by the most recent figures of production. For our present purpose our survey must be on broad and simple lines, which will enable us to grasp the whole question in due proportion and in its true perspective. Proportion and perspective, as the exponents of the doctrine of relativity might remind us, depend entirely on the point of view of the observer. The facts and figures of the fuel resources of the world are the common property of the experts of all the civilised nations. They may be regarded as being like the immutable laws of Nature, but the proportion and perspective in which these facts and figures range themselves are different for the observers and commentators of each of these nations. In our own survey we shall be wise to have in our minds some recognition of these widely different points of view.

In Great Britain, as a maritime nation, we cannot, either on political or commercial grounds, ignore the points of view of other nations inside or outside the circle of the Empire.

An interesting review of the world's coal supply in 1920 is given by the United States Geological Survey. The total output, including brown coal and lignite, amounted to 1,300,000,000 metric tons. This is within 3 per cent. of the maximum output which was reached in 1913 and 1918. Of this total output:—

	Per Cent.
The United States of America produced	45
Great Britain and the British Empire produced	22
Germany produced	19
Other countries, ranging from 2½ per cent. downwards produced	14
	100

One of the most significant features revealed by this survey is the remarkably rapid development in the winning and use of brown coal and lignite in Europe, and particularly in Germany. The output in Germany in 1919 had reached the huge figure of 93·8 million tons, but this was overtopped in 1920 by an output of 111·6 tons, an increase in one year of nearly 18,000,000 tons. The total European output in 1920 amounted to 140·7 million tons, made up as follows:—

	Million Tons.
Germany	111·6
Czecho Slovakia	19·7
Jugo-Slovakia	2·5
Austria	2·4
Italy	1·6
Netherlands	1·4
France	1·0
Spain	0·5

The output of ordinary coal in Germany for 1920 was 140·8 million tons. The brown coal industry in that country is of old standing, and its rapid development in recent years is based on sound knowledge and experience. Though in its natural state a less concentrated fuel than bituminous or anthracitic coal, brown coal has many points in its favour. The chief of these is the low cost

* James Forrest Lecture, delivered at the Institution of Civil Engineers on Tuesday, June 28.

at which it can be won as compared with ordinary coal. Where extensive deposits of great thickness occur, these can be worked opencast, and excavated by machinery. The winning of brown coal is thus on an altogether different basis from coal mining, with its deep and costly underground roads and workings, which involve heavy costs for timbering, pumping and ventilation. The manual labour required is much smaller in amount for a given output and is of a less highly specialised type, while the special dangers and uncertainties of coal mining are practically absent. The capital charges, being mainly on surface roads and on excavating machinery, are relatively light, as compared with the heavy initial and permanent charges involved in the sinking and equipment of shafts or mines. Brown coal, though it contains from 40 per cent. to 60 per cent. of water is to-day by far the cheapest source of thermal units. Its further manufacture by drying, briquetting and carbonisation can be carried out close to the point of excavation and under conditions favourable to production on a large scale, and therefore at a low cost.

The glowing accounts of this development which have appeared in the technical press during the past two years may have struck us as exaggerated; but the solid fact remains that the output of lignite in Germany last year was 111 million tons. Germany has already faced the fuel problem of the future so far as she herself is concerned.

In view of the hard facts and figures which are now before us, it is not surprising that Germany's example is being followed, not only in Central Europe, but in Victoria and Canada.

In Victoria extensive deposits of brown coal exist in Central Gippsland, which are estimated by Mr. H. Herman, the Director of Geological Survey, to contain 30 thousand million tons. The main deposits near Morwell are hundreds of feet in thickness, and lend themselves admirably to opencast working on an enormous scale. Considerable progress has already been made in the development of these deposits; and since the commencement of operations in 1916, 400,000 tons of brown coal have been mined and sold. When the excavating methods become more perfectly organised, it is anticipated that the coal will be produced at the mines at 2*s.* 3*d.* per ton. It contains from 40 per cent. to 50 per cent. of water, so that in heat value 2 tons is equal to about 1 ton of ordinary coal. A 50,000-kw. generating station is being installed at Morwell for the transmission of current to Melbourne. Though a considerable market appears to exist for the coal as it is mined, it is intended to establish briquetting and carbonising plant at the mines, so that fuels of higher availability will be produced from the raw coal. In 1920 a sample of this coal was received here, and experiments on its carbonsiation were carried out at the Fuel Research Station.

In the Dominion of Canada experiments are in progress on the briquetting and carbonisation of the brown coals of Manitoba and Saskatchewan. These experiments are being carried out under auspices of the Dominion Government and of the Government of the Province of Saskatchewan.

Somewhat allied to the lignite problem is that of the development of peat as a fuel. The Dominion Government of Canada is keenly interested in this question, and I shall have something more to say on the subject at a later stage. Germany also is preparing for important developments, some of which are described in the *Engineer*, of April 22, 1921. The Wiesmoor plant, which has been in use since 1910, is now regarded as obsolete, but during the 10 years it has been in use, much valuable experience has been gained on the winning and use of peat. The average fuel consumption is stated to be from 2·7 kilos to 3 kilos of partially dried peat sods per kilowatt hour, and the cost of the peat is taken at 5 marks per ton. It is now proposed to establish a line of generating stations fired by peat extending from Konigsberg on the east to Wiesmoor on the west.

The world's output of brown coal and lignite in 1920 was about 143 million tons, or 11 per cent. of the total coal output of 1,300 million tons. From the European point of view the significance of this fact must not be gauged in terms of this moderate percentage. According to the extent to which Germany can meet her own requirements for heat and power by the development of lignite, peat and water power, the output of her coal mines will be set free for export, and she will thus take a more important place in the markets of the world. The coal owners and miners of this country would be well advised to keep an eye on the development of brown coal and lignite in Germany and elsewhere.

Turning now to oil, the other great natural source of fuel, we find that the world's output for 1920 was about 97 million tons, of which—

	per cent.
The United States produced	64·8
Mexico produced	23·3
Russia produced	3·5
Dutch East Indies produced	2·5
India produced	1·2
Roumania produced	1·1
Persia produced	1·0
Countries producing less than 0·5 per cent. produced	2·6
	100·0

The oil putput therefore amounted to 7 per cent.of the fuel output of the world, reckoned in tons. If reckoned in potential therms, the figure would be raised to 10 per cent.

As the United States has extensive oil interests in Mexico, it may be taken that last year she controlled 75 per cent. to 80 per cent. of the total output of the world. It is therefore significant that, in official quarters, grave anxiety has been expressed as to the probable exhaustion of these resources in view of the rapid development in the use of motor spirit for road transport and of fuel oil for transport by sea.

While we are justified in discounting to some extent the elements of popular panic which have been obvious in much that has appeared in technical journals, as well as in the daily press, the fact remains that, but for the rapid development of production in Mexico, and the extensive interests of the United States in this production, the actual danger of shortage in America would have already become more acute.

The following extract from a statement by Mr. J. O. Lewis, Chief Petroleum Technologist to the United States Bureau of Mines, expresses so very clearly the American view of the oil problem of the future that I cannot do better then quote it *in extenso*. No mere paraphrase would convey the same impression of reality.

"The United States Geological Survey during the last ten years has made several estimates of the quantity of oil left in our oil fields. The most recent estimate, that of David White, indicates that about 40 per cent. of the oil had been brought to the surface, and that the 60 per cent. remaining underground, if recovery indeed were possible, would last barely twenty years at the present rate of consumption. As the period in which an oilfield can be made to yield its oil is not wholly within the control of man, the domestic production will undoubtedly be spread over a much longer period than that estimated; but on the other hand, the peak of production will be passed long before twenty years, and thereafter production will be at a declining rate. Of course, such estimates are by no means infallible, as many obscure factors are involved. However, this statement represents the opinion of the agency best qualified to make such an estimate, and is indicative of a condition which, were there no other solution to the problem, would be highly unsatisfactory, and would be viewed by the automotive industry with the greatest concern. For, even were the estimate unduly pessimistic, and the actual reserve twice that shown, the condition would still be unsatisfactory.

"The preceding statement refers only to the oil from oil wells in the United States. Fortunately, there are enormous undeveloped resources in the rest of the world. The petroleum resources of this country have been developed and depleted in a ratio far beyond that of other countries, so that although we are producing to-day two-thirds of the world's production, the opportunities elsewhere for increasing production are much greater than in the United States. Geologists and those well informed on foreign resources believe that in all probability the world contains enormous reserves of oil that can be obtained upon demand. Although to obtain oil from these reserves may not be as satisfactory as to obtain it within the confines of the United States, the outlook tends to assure the future of the internal-combustion engine.

"Fortunately, oil may be obtained from other sources than oilfields. In various parts of the United States, particularly in Colorado, Wyoming and Utah, are enormous bodies of oil shales from which oil may be obtained by destructive distillation as benzol is obtained from coal. The United States Geological Survey has estimated the quantity of oil locked up in the richer shales of the three States mentioned as perhaps ten times the amount of the oil reserves in the oil fields. In Scotland, the retorting of oil from oil shales has been on a commercial basis for more than fifty years and antedates the oil industry in the United States. Commercial and semi-commercial experiments are being made in order to determine whether the oil shales of the Western States can be mined and retorted profitably in competition with petroleum from oil fields. This problem has not yet been solved, but these shales constitute a latent reserve that protects the future needs of the country for motor fuel as far as these needs can be foreseen. However, oil cannot be obtained from the shales on a large scale without heavy investments, and the development of the industry must be spread over many years. Also, when that time comes, the consumer will probably have to pay more for his gasoline.

"As regards the question of substitutes, if prices of petroleum products advance sufficiently, alcohol may become one of the motor fuels of the future. The efficient use of alcohol requires, however, certain modifications in the present design of the mobile internal-combustion motor. Moreover, large quantities of lubricants are required, in addition to motor fuel. Hence it seems desirable to continue to depend on crude oil as a principal source as long as possible, especially as crude oil is the only known satisfactory raw material yielding both motor fuel and lubricants.

"Briefly, motor fuels may be obtained from four possible sources: (1) Petroleum from our own wells, (2) petroleum from wells in foreign countries, (3) oil from our oil shales, (4) gasoline substitutes. As to the first, there is serious but not immediate concern; as to the second, it is believed that there remain enormous potential reserves outside of the United States; as to the third, there are known deposits of oil shales which, in three States alone, promise to yield many times more oil than will ever be recovered from our oil wells: as to the fourth, it is probable that eventually alcohol could meet our needs should gasoline fail. Thus, while there is concern over our own domestic supplies of petroleum from oil wells, there is no concern as to the ultimate supply. There may be critical periods when one source fails and before another has been sufficiently developed, also it is not unlikely that when our own wells fail and we have to fall back on oil from foreign countries or oil shales, we shall have to pay more for our motor fuel."

In view of this reference to alcohol as a probable substitute for motor spirit, it may be well here to refer to the action of the British Government in that connection.

In view of the national importance of the subject, Mr. Walter Long appointed a committee in October, 1918, to consider and report upon:—

(1) The various available sources of supply of alcohol, the methods of manufacture and the cost of the product.

(2) The suitability of alcohol, either alone or in admixture with solid, liquid or gaseous combustible substances, for use in internal-combustion engines, and the modifications of the existing types of such engines which may be necessary to the attainment of efficiency.

(3) The question of denaturing the alcohol and the alterations to be made in the present Excise Bill.

The committee obtained much useful information of a preliminary nature; and in June, 1919, issued a report which was presented to Parliament on June 30.

One of the recommendations of the report was: "That an organisation should be established by the Government to initiate and supervise experimental and practical development work at home and overseas, on the production and utilisation of power alcohol, and to report from time to time for public information on all scientific, technical and economic problems connected therewith."

This report was in due course considered by the Committee of Council for Scientific and Industrial Research, and they recommended the Fuel Research Board to continue the investigation of these problems.

As a first step in these inquiries, the Fuel Research Board recommended the appointment of Sir Frederic Nathan as Power Alcohol Investigation Officer. This appointment was confirmed by the Lord President on December 17, 1919. Since his appointment, Sir Frederic Nathan has devoted his whole time to these inquiries, and has been in close touch with the Government Departments interested in the questions involved.

In July, 1920, an interim memorandum on "Fuel for Motor Transport," was published by the Fuel Research Board, in which the situation at that date was summed up as follows:—

"The main sources of alcohol are vegetable materials containing starch or sugar, and practically all the alcohol for potable and industrial purposes is now made from grains or molasses. Before the war large quantities of alcohol were made in Germany from potatoes specially grown for the purpose.

"Alcohol can also be produced from the fermentable sugars formed by the hydrolysis of wood cellulose, and synthetically from calcium carbide or from the ethylene contained in coke oven and coal gas. The quantity of waste wood in this country for alcohol production is, however, negligible; calcium carbide is impossible, as it cannot be produced in quantity without cheap power and the recovery of ethylene from coke-oven and coal gas, and its conversion into alcohol are still in the experimental stage. At the present time, therefore, none of these three sources of supply is of appreciable commercial importance in this country.

"The vegetable materials growable in this country from which alcohol could be made are grain (barley), potatoes and mangolds, and the following figures relating to the production of 250,000,000 gallons of 95 per cent. alcohol are interesting:—

	Quantities.		Acreage.*		Raw Material.	
	Required for 250,000,000 Gallons.	United Kingdom Production, 1919.	Required for 250,000,000 Gallons.†	Under Crop in 1919.	Average Price per Ton, in 1919.	Cost per Gallon of Alcohol.
	tons.	tons.			£ *s.* *d.*	£ *s.* *d.*
Grain (barley)	4,170,000	1,288,035	5,593,293	1,870,087	21 4 0	0 7 0
Potatoes	12,500,000	6,312,000	2,118,644	1,218,774	8 10 6	0 8 6
Mangolds	25,000,000	7,769,000	1,282,513	471,759	1 10 0	0 3 0

* Total arable acreage of the United Kingdom about 21,000,000 acres.
† Based on ten years' average yields.

"These figures are not encouraging, and generally it may be stated that the production of alcohol in any considerable quantities from vegetable materials grown in the United Kingdom is not economically possible owing to: (1) Insufficient acreage, (2) the high cost of cultivation and harvesting, (3) the high cost of manufacture, and (4) the fact that the most suitable raw materials are also important foodstuffs. There is for these reasons no prospect of replacing any considerable quantity of petrol by home-produced alcohol. Moreover, it is unthinkable that land, for even a fraction of the quantity of the raw materials in the above table, could be used for such a purpose, when in the matter of food production, a week-end supply only is assured from our own land.

"Considering next the production in the Empire outside the United Kingdom, molasses is the raw material

which can be converted into alcohol most cheaply. Molasses is a by-product of sugar-refining, and the quantities available for the manufacture of alcohol are therefore dependent on the refined sugar output. The estimated Empire production of refined sugar in the season 1919–20 is just over 1,000,000 tons; and the whole of the resulting molasses would only produce about 17,000,000 gallons to 18,000,000 gallons of 95 per cent. alcohol. Considerable quantities of molasses are used in this country for the manufacture of industrial spirits. The output of the home distilleries equipped for the production of molasses alcohol is limited, however, to, say, 7,000,000 gallons or 8,000,000 gallons of 95 per cent. alcohol, and in view of the present cost of materials and labour, and of freight, it would hardly be a commercial proposition to erect additional distilleries here for the purpose; it would be better to convert the molasses into alcohol where it is produced, to use the alcohol where it is made to supplement or replace petrol, and to export the balance. With the present increasing output of cane sugar, there should be very considerable quantities of molasses available for the manufacture of power alcohol, and the possibility of utilising these molasses is being brought to the notice of the authorities of the countries concerned. Even under the most favourable circumstances, however, the quantities of power alcohol available from this source must be, as shown above, comparatively small, and will in the first instance mainly be used in the neighbourhood of its production in replacement of petrol.

"Some of the legislative questions which arise in connection with the use of alcohol for power purposes have been dealt with in the Finance Bill for this session. A section of the Bill provides for the use of a new description of methylated spirits, to be called 'power methylated spirits,' for generating mechanical power, and for the payment of the same allowance in respect of such methylated spirits as applies to methylated spirits used for industrial purposes, namely 3*d.*, a proof gallon. It also gives power to the Board of Customs and Excise to make regulations as to the composition and quantity of the denaturant. A denaturant will shortly be authorised for power methylated spirits, which it is hoped will reduce to the minimum the cost of denaturing spirits to be used for this purpose. Clauses will also be inserted into the forthcoming Revenue Bill extending facilities for the importation and distribution of spirits in bulk, and enabling the Board of Customs and Excise to make regulations providing for the use of alcohol in generating mechanical power.

"While it is necessary, in view of the high duty on spirits in this country, to maintain some restrictions upon their use free of duty, one result of the Government action will be that the production and use of alcohol for power purposes will be much facilitated and the expense connected with any necessary restrictions will largely disappear."

As regards the work of the past year, Sir Frederic Nathan reports that experiments carried out on the cultivation of Jerusalem artichokes have indicated that very good yields of alcohol per acre could be obtained from them; these experiments are being repeated this year, and if the previous year's results are confirmed, it may be desirable to consider the possibility of growing this tuber to supply a limited quantity of alcohol for special purposes, such as aviation. An examination of the artichoke stems has indicated that it may be possible to convert them by a simple treatment to paper pulp. Should this prove to be the case, both products would be cheapened.

The investigations as to the possibilities of producing alcohol in the Empire overseas are still in progress. So far as they have gone, they indicate that in the sugar growing countries, molasses, from which alcohol might be obtained, is being wasted, but that the quantities are comparatively small, and in most cases would be insufficient to meet even local requirements for alcohol. Alcohol might be made from suitable crops grown specially for the purpose in those Dominions and Colonies where labour is available, and used to supplement or take the place of supplies from the above sources. Some such course is specially desirable where petrol is dear and difficult to obtain, for instance, in the East African Protectorates and West African Colonies, which are, moreover, very dependent on motor transport for their development.

The use of cellulosic materials is not yet possible, because although research work is in hand to find a process that could be employed on a commercial scale in those regions where such materials exist in sufficient abundance, it has not so far led to any definite results. Where, however, materials capable of easy hydrolysis exist, as for instance is the case with waste raw rice, the recent large scale experiments in Burmah carried out under the auspices of the Burmah Oil Company, appear to indicate that the joint production of alcohol and paper should be a commercial possibility. (*Vide* Sir Charles Bedford's paper in the Journal of the Royal Society of Arts, June, 1921.)

Until alcohol can be made from waste materials which can be collected and treated at small cost, it does not seem likely that Empire-produced alcohol can be imported into this country on any considerable scale; it is improbable that it can be produced cheaply enough or in sufficient quantities from materials grown for the purpose in those overseas portions of the Empire which will no doubt before long, produce it in this way for local consumption.

The Finance Bill of 1921 contains clauses giving the Commissioners of Customs and Excise powers to make regulations with respect to spirits manufactured otherwise than by distillation, and with respect to the manufacture, storage, removal, sale, use and supply of power methylated spirits, and the importation, storage, removal and use of spirits to be used in the manufacture of power methylated spirits.

Another of the fuel problems of the future is the winning and utilisation of peat. The history of the association of the Fuel Research Board with this problem has been given in various publications of the Department of Scientific and Industrial Research. Among these the Report of the Irish Peat Enquiry Committee, of which our past President, Sir John Purser Griffith was the Chairman, stands out most conspicuously. This subject would in itself supply material for many lectures, but on the present occasion it can only be briefly referred to in its relation to the subject of our consideration to-night.

Reference has already been made to the extensive peat developments which are in progress in Germany. These are based on the experience gained at the Wiesmoor Peat Station, which has been in operation since 1910. The peat is dredged, macerated and spread on the surface of the bog to dry. By stacking under cover the moisture of the peat blocks can be reduced to 25 per cent. solely by air drying. It has been stated that, prior to the war, one ton of air-dried peat containing 25 per cent. of moisture could be produced for 4 marks. For steam raising purposes two tons of this peat are equal to about one ton of coal. At the Wiesmoor Station eight water tube boilers are fired by peat. The new stations in Germany are being designed on a much larger scale, and no effort is being spared to render them as perfect as possible.

These schemes appear to ignore the fundamental difficulty which applies to the winning of peat in quantities sufficient to meet the day by day requirements of any large central station. When it is realised that the peat deposit in a good bog 20 ft. deep, is only the equivalent of a 12 in. or 14 in. seam of coal, it will be evident that even an output of 1,000 tons a day of air dried peat involves the laying out and development of an enormous surface. At the Zehlonbruck plant, near Konigsberg, it is proposed to use 920,000 tons per annum, or about 2,500 tons per day.

Professor Purcell informs me that to win mechanically 900,000 tons of air dried peat in one season at least 4,500 men, women and children would be required, and the area over which the spreading and drying operations would extend could not be less than 9,000 acres, or say 15 sq. miles. He suggests that in dealing with any production over 60,000 tons to 80,000 tons per annum from any single district, the difficulty would increase as the square of the production.

The Irish Peat Enquiry Committee was fully informed as to the position of peat winning in Germany prior to the war, and also to the earlier survey and investigation work of the Canadian Department of Mines. In April, 1918, a Peat Committee was set up by the Federal Government, in co-operation with the Government of the Province of Ontario, to investigate the possibility of manufacturing peat fuel on a manufacturing scale. The Alfred Peat Bog, on which the work of the Committee is being carried out, is about 43 miles east of Ottawa, and about 70 miles from Montreal. Last summer Professor Pierce Purcell, the Peat Investigation Officer of the Fuel Research Board, visited the experimental station at this bog, and carefully studied the results which had been achieved under the direction of Mr. E. V. Moore, who is the engineer in charge. Professor Purcell was able to watch the harvesting operation over a period of weeks, and obtained much useful information as to machines and methods. His discussions with Mr. Moore were most useful, and on his return to this country he presented to the Fuel Research Board an exhaustive report on his visit. During the present season, Professor Purcell hopes to visit the peat stations in Sweden, Germany, Denmark, Holland and France. We shall thus be in intimate touch with all the more important developments which are in progress, and the Fuel Research Board hope, by continuing the publication of full reports to serve as a useful centre of information on this subject.

With regard to the Board's own activities, these were necessarily seriously curtailed by the war, and the post-war conditions in Ireland. Last season, however (1920) peat was cut, macerated, spread on a bog at Turraun, air dried and harvested there.

At the beginning of the present year, 100 tons of this air-dried peat were sent to the Fuel Research Station, where some interesting experiments were carried out on its use for boiler firing and for carbonisation. The peat, when it reached the station, contained about 27 per cent. of moisture. After having been kept under cover for some months the moisture was reduced to about 17 per cent. This peat is in the form of hard blocks of various lengths, up to about 10 in., with a cross section of something like 2 in. by 2 in. Its density is rather under 1, or about twice that of the ordinary hand-cut sods made on the same bog. The blocks can be sawn and cut like hard wood, and they stand transport with very little breaking up into smalls. In this respect they contrast very favourably with the ordinary hand-cut sods which break down seriously in transport by rail or road.

The result of last year's experience at Turraun show that:—

(1) Machine peat dries more quickly than "cut peat" under equal weather conditions.

(2) Peat spread during August and even as late as September 3, will have dried sufficiently (say, to 35 per cent. moisture) to be used as a fuel.

(3) It was possible in the wet and unfavourable season experienced to dry three separate spreadings of peat on the same area.

(4) The peat cut and spread as early as February 5 was little damaged by the rain and frost in the early part of the year, and was harvested, although four months was required to complete the process.

(5) The peat winning season at Turraun extended over seven months last year, namely from February 5 to September 3.

(6) Machine peat can be "footed" when containing 75 per cent. moisture or less, and may be "clamped" when containing 40 per cent. to 50 per cent. moisture. Slow final drying is necessary to get the best results with machine peat, and it is advisable that this should be done in a large "clamp," the toughest blocks being thus produced.

(7) The season referred to had been one of the wettest experienced for some years. In six out of eight months the rainfall exceeded the average for the past five years, and although June was a dry month, there were 163 rainy days in the eight months.

Steam-raising trials at the Fuel Research Station have shown that the peat in this form is an excellent fuel. Though the evaporative efficiency actually obtained was only 65·4 per cent., this was obviously due to the unsuitability of the furnace arrangements. Further trials will be made under more favourable conditions.

Peat blocks lend themselves admirably to carbonisation, either in vertical retorts at temperatures between 700 deg. and 900 deg. C., or in steel retorts at 550 deg. to 600 deg. C. The charcoal resulting from carbonisation is an ideal fuel for suction-gas producers. The oils obtained by carbonisation are now being examined.

As coal is likely to remain the chief source of fuel, not only for Great Britain, but for the world at large, the problems of its winning, preparation and use still occupy the foreground in all serious consideration of the subject. In the solution of these problems there is ample scope for the skill and enterprise of an increasing number of fuel experts and engineers, not only in the pioneering work of experiment and inquiry, but in the organisation and development of new methods as these are evolved.

In seeking to come to closer quarters with these questions it may be helpful if we can set them out with some sense of proportion and perspective as they appear from the British point of view. We know, broadly, that in normal times before the war, the annual output of coal of the mines of the United Kingdom was approximately 287,000,000 tons, of which 189,000,000 tons were consumed as follows:—

	Million Tons.
1. Railways	15·0
2. Coasting steamers	2·5
3. Factories	60·0
4. Mines	20·5
5. Iron and steel	31·0
6. Other metals...	1·3
7. Brick works, potteries, glass and chemicals	5·8
8. Gas works	18·0
9. Domestic	35·0
	189·1

If from this total we deduct items 5, 6 and 8 (iron and steel, other metals and gas works) together, say, 50,000,000 tons, the balance of 139,000,000 tons represents the amount which is burned in the raw or natural state of the coal. The greatest of the fuel problems of the future is to decide what proportion of this huge total it will pay to subject to a preliminary operation of carbonisation or gasification, with the object of sorting out the potential thermal units of the coal into groups of higher availability or greater convenience as fuels, *e.g.*, gas, motor spirit, fuel oils and coke.

Though the operations of carbonisation and gasification involve the expenditure and loss of some of the thermal units of the coal, so that the collective thermal value of the new fuels is less than that of the original coal, yet the loss may be more than compensated for by the increased value of some of the new fuels.

At the prices of to-day a "therm" in the form of coal costs from 1*d.* to 2*d.*, while in the form of motor spirit its cost is from 20*d.* to 25*d.*, and in the form of town gas 10*d.* to 15*d.* These figures show the premiums which can be paid for the higher "availability" of special fuels. The general recognition of the value of the availability and convenience of the more costly forms of fuel must not tempt us to overlook the necessity for a critical examination of the uses to which the more expensive fuels are being devoted.

In the case of motor spirit, there is a decided tendency to regard mere convenience as a sufficient justification for its use. While for swift transport by air and road there is no cheaper substitute in sight there are good grounds for believing that, for the heavier forms of traffic motor spirit may be replaced by much less expensive fuels. A certain amount of success has already been attained in the use of small suction gas producers in the slower and heavier classes of motor vehicles. The most hopeful prospect in this direction appears to me to be based on the designing of small suction-gas producers for definite types of solid fuel. The inventor, too often feels that the success of his invention will depend on its adaptability to a great variety of conditions, and he fails to make any one successful design by attempting to deal simultaneously with a number of variables.

Small suction-gas producers for motor vehicles ought in the first instance to be definitely designed for, and worked with, one definite type of solid fuel. Anthracite, low temperature coke, wood, charcoal and peat charcoal, each have their special characteristics, which will affect the design and working of the gas producer. The more important features which must be taken into account are: freedom from tarry or oily impurities, density, inflammability and the quantity and nature of the mineral ash.

Before considering in more detail the role of carbonisation and gasification at various temperatures as a means of sorting out from raw coal solid, liquid and gaseous

forms of fuel, let us pass in review very broadly, the uses to which the 139,000,000 tons of coal are put which is consumed in the raw state.

We all take our share in the consumption of the 35,000,000 tons of coal which is devoted to domestic use; and most of us have a kindly feeling for our old friend the open fire. The work of Dr. Margaret Fishenden on open fires has definitely shown that, under reasonable conditions of firing, 20 per cent. of the total potential heat of the raw coal is radiated into the room, and that a further 20 per cent. to 30 per cent. is given up to the fabric of the building before the waste products of combustion leave the chimney. Smoke and soot are, however, an unduly heavy price to pay for the transient cheerfulness of the flaming coals in a well-stoked fire, especially when we remember that over long periods the ordinary fire is only smouldering and dreary looking. The coal-fired kitchen range, unlike the open room fire, has few, if any, sentimental associations, and its replacement by gas cookers and coke-fired water heaters is only a matter of time.

I have for many years taken a deep interest in the production of solid smokeless fuel for domestic purposes by the carbonisation of selected coals at 550 deg. to 600 deg. C. The resulting coke is entirely free from smoke producing hydrocarbons, while still containing 10 per cent. to 12 per cent. of volatile combustible matter, which burns with a slightly luminous, perfectly smokeless flame. When the coke is kindled, it becomes enveloped by these flames, which quickly raise the surface to incandescence. Undoubtedly, if this smokeless solid fuel could be produced at a cost permitting of its being sold at little more than the price of the coal which it would replace, it would lead to a complete revolution in domestic heating, and among other good things, to the abolition of black smoke from house fires. This attractive prospect has been spread before our eyes for many years by enthusiastic inventors and company promoters, yet its realisation seems always to move a little further into the future.

The problem really has two distinct sides—the technical and the economic. On the economic side the data for a final solution will only be obtained after the technical solution has been reached. In other words, until a fair sized industrial plant has been carried on continuously over a long period, making and disposing of all the products of carbonisation under steady market conditions, no one can say whether or not the business will be a profitable one.

On the engineering side, an efficient and not too costly apparatus must be designed and constructed in the working of which manual labour, fuel consumption and maintenance costs are all reduced to a minimum. In these respects—as well as in its output capacity on a given ground area—the apparatus must stand comparison with gas retorts and oil shale retorts of the most modern types. Only when this ideal has been realised practically can the future of low temperature carbonisation as a business proposition be put to the test of continuous working on a large scale under the labour and market conditions of the day.

From the experience of the past two years at the Fuel Research Station with a considerable variety of coals, we know with certainty the yields and quality of the gas, oils and coke produced under definite conditions, but this knowledge is only the first step in the inquiry. For, until we know with equal certainty the cost of producing these, and the markets in which they are to be disposed of, no economic balance sheet of any real value can be arrived at.

Let me illustrate the market uncertainty by a few comparative figures. Assume that 15 gallons of fuel oil suitable for naval use can be obtained from a ton of coal. Six months ago the value of this oil could safely be taken at 1*s.* per gallon, and the 15 gallons would have realised 15*s.* To-day the price of this oil is only 4*d.* per gallon, and the product would therefore only realise 5*s.*; a drop of 10*s.* per ton on the coal carbonised. It is obvious that a method of carbonising which would have paid its way handsomely six months ago would to-day result in a loss. My own belief is that low temperature carbonisation can only be established on a sound commercial basis with low operating costs and a very moderate margin of profit.

Prior to 1914 the shale oil industry in Scotland was distilling 3,000,000 tons of shale per annum. The entire cost of the carbonising operation, for labour maintenance and fuel, was 1*s.* 6*d.* per ton, and the margin of profit on which fair dividends were paid was 2*s.* 6*d.* per ton. Unless the costs and profit margins of low temperature carbonisation can be reduced to the modern equivalents of these figures, the prospects of its development on a great scale are not hopeful, from the national point of view.

If low temperature carbonisation is proved to be a feasible operation commercially, it would find its first and most natural application to the 35,000,000 tons of coal used for domestic purposes. Were this coal all carbonised, it would produce about 2,000,000 tons of fuel oil for the navy, and considerably more than the peace requirements, though considerably less than the war requirements. The motor spirit produced would amount to about 100,000,000 gallons.

The capital expenditure required for the installation of carbonising plant for 35,000,000 tons of coal per annum would be of the order of 30,000,000 to 40,000,000 sterling. A gross profit of 5*s.* per ton of coal carbonised would provide 10 per cent. for interest and 10 per cent. for depreciation on this expenditure.

The application of low temperature carbonisation to raw coal which is used in the industries must necessarily depend on the successful solution of the technical and engineering problems to which reference has been made. In this case also the future possibilities of this application depend entirely on the evolution of apparatus and method which will reduce the capital and working charges of the operation to a minimum.

When coal issued for steam raising under the best known conditions, it is obvious that there is little to be gained in thermal efficiency by any preliminary sorting out of the thermal units of the coal into fuels of higher availability. It is well known that an efficiency of 75 per cent. to 80 per cent. is attainable in steady practice. This is borne out by the results of the working during the first quarter of the present year at the two London power stations to which reference has already been made. At the station of the Central Electric Supply Company, the average efficiency, less banking, was 75·5 per cent., though the average percentage of ash was 18·4. At the Durnford-road power house the average efficiency was 78 per cent. and the average percentage of ash was 16. Supposing the coal used at these stations had been submitted to preliminary carbonisation and its thermal units sorted out, into the forms of gas, tar and coke, how would this have effected the evaporative efficiency? Of the total thermal units of the coal:

	per cent.
The coke would contain	70
The gas would contain	12
The oils would contain	11
	93
Intrinsic thermal loss 7	
Heat to be supplied for carbonisation 6	
—	13
Net thermal value of the products ...	80

The high thermal availability of the rich gas would be thrown away if it were used for steam raising, the fuel oil would be a boiler fuel decidedly superior to the original coal, and the coke would not be of more than equal value to the coal. Solely from the steam raising point of view, therefore, a thermal loss would result, and not a gain, from the operation.

I at once admit that in special cases this thermal loss might be compensated for if a local market for the rich gas were available. In most cases, however, the margin of profit would be much too small to justify the extra capital expenditure which would be required.

The valuable papers of Mr. D. Brownlie* throw a much-needed light upon the use of coal for steam raising. His analysis of the statistics which he has collected shows that the amount of coal used for steam generation in this country for heat and power production is from 75,000,000 to 100,000,000 tons per annum, or about one-half of the whole coal consumption. Mr. Brownlie's conclusions as to the comparative efficiency of the numerous boiler plants he has personally examined during the past seven or eight years, and the extension of these conclusions to cover the whole steam raising practice of the United Kingdom, supply us with material of which some broad generalisations may be based.

Mr. Brownlie divides the existing boiler installations of the United Kingdom into three classes: bad, average, and highly efficient. Of the total number, 10 per cent. are bad, 85 per cent. are average, and 5 per cent. are highly efficient. As regards the efficiencies of each class, with water tube boilers, bad give 61 per cent., average give 69 per cent., and highly efficient give 82 per cent., while with Lancashire boilers, bad give 49 per cent., average give 60 per cent., and highly efficient give 79 per cent.

If we take the minimum figure of 75,000,000 tons as the amount of coal annually used for steam raising it is clear that the scope for economy is enormous; for even a moderate increase of efficiency of 10 per cent. over all would result in a saving of 7,500,000 tons per annum. Mr. Brownlie's own experience of the savings to be effected by the reorganisation of existing plants leads him to take a much higher saving as a possibility. In the case of the colliery steam boiler plants, the average efficiency of which he places at 51 per cent., he estimates that the coal bill for all the colliery plants in the country is 18,500,000 tons, and that the efficiency might easily be raised by 10 per cent. to 15 per cent., while by the systematic use of colliery waste a further saving of saleable coal would be realised.

Mr. Brownlie's facts and figures are well worth the careful study of all who are seriously interested in fuel economy. They show the enormous possibilities in this direction which are actually within our grasp if we will only avail ourselves of the knowledge which already exists. No new and revolutionary discoveries are required for their realisation. The problem of the future which awaits solution is how to stimulate the practical interest of the owners of steam-raising plant throughout the country. It may be that the permanently increased cost of coal will supply the necessary stimulus, but this will only begin to take effect when the industry has settled down to more normal conditions. For steam raising in this country the cheapest form of fuel is coal or coke if it is used under reasonably scientific conditions, and so long as this is the case, the use of fuels of higher availability will only be economically practicable under very special conditions.

In America the use of pulverised fuel is making steady progress, not only for metallurgical purposes, for some of which it is very suitable, but even for steam raising. The case for steam raising by this method is still, however, by no means clear.

The primary object of the coke industry is the production of hard coke for the manufacture of iron and steel. The coals used must be of a special type. The therms obtained in the form of gas, though of high availability, are primarily used for the heating of the coke ovens for which therms of lower availability would do equally well. In a few cases in this country the surplus gas is sold to gas undertakings in the neighbourhood of the coke ovens, and in that case full advantage is taken of its high availability.

In Northumberland and Durham the surplus gas from the coke ovens is used for the generation of electricity by steam boilers and engines, the current produced being fed into the main circuit of the Newcastle Power Company. In this case the high availability of the gas therms is thrown away in doing work which could be done equally well by cheaper therms in the form of coal or coke. The tar and ammonia which are recovered from the coke ovens take their place side by side with the same products of carbonisation in gas works. The hard coke, owing to its density and the practical absence of volatile matter, is quite unsuitable as a domestic fuel, except in specially-constructed stoves or water heaters.

The future development of the coking industry must mainly be determined by its intimate association with the iron and steel industry.

In the gas industry the fuel problems of the future have a new interest since the publication of the report of the Fuel Research Board on the results of their inquiry into the subject of gas standards. As you are no doubt aware, the results of this inquiry led to the adoption by the Board of Trade of a new method of charging the consumer for the gas which passes through his meter. The volume of this gas is still measured and recorded, but the consumer no longer pays on thousands of cubic feet, but on the product of the multiplication of the number of cubic feet passed by the standard calorific value of the gas per cubic foot. The unit of charge is the "therm," which is the name adopted for 100,000 British thermal units. Under this system it is now possible to give to the gas undertakings a wide latitude in the selection of the standard of calorific value which they adopt, and therefore a much wider choice of the methods by which the gas is manufactured. In the report it was stated that the great gain for the gas undertaking under the new system would be that no undue legislative restrictions would limit them in their development of the most economical production of thermal units in the form of gas. It was pointed out that there was still great scope for this development; as, according to present practice, only from 21 per cent. to 24 per cent. of the total potential thermal units of the coal is being sold in the form of gas.

To increase this percentage two methods were available, both depending on the production of water gas by one or other of the reactions between steam and carbon at a high temperature. The first of these methods was the old-established one in which a portion of the coke produced in the retorts was transferred to a separate producer, in which it was raised to bright incandescence by an air blast, and then subjected to the action of a current of steam. The thermal efficiency of this operation ranged from 45 per cent. to 55 per cent., according to the method of blowing up and steaming adopted. The second method had recently been chosen in connection with vertical retorts. In this case the water-gas reactions are carried out in the lower part of the column of red hot coke in the retort itself, by passing through it a current of steam. The volume of gas produced is much increased, though its calorific value is reduced by the addition of water gas to the hydrocarbon gas resulting from the carbonisation of the coal.

It was foreseen by the Fuel Research Board that the introduction of the new thermal standard would open the way to a more general adoption of this method, and a setting of vertical retorts was installed at the Fuel Research Station with the object of obtaining trustworthy data as to the conditions and the limitation of the steaming process. A full report on the results of the experimental working during the past year was recently presented to the Institution of Gas Engineers.

As the experimental plant of the Fuel Research Station is especially adapted for the obtaining of full and accurate thermal and other data, it is now possible to speak with considerable confidence on the economic bearings of this process as applied to several distinct types of coal. Two of the questions which it was proposed to answer were:

(1) Under pre-arranged conditions of temperature and percentage of steam, how will the yields of the principal products, gas, tar, coke and ammonia, be affected in different types of coal.

(2) To secure the increased yields of products, how much extra heat must be supplied to the retorts?

The gain which is of most importance to the gas industry is that of "therms" in the form of saleable gas. It had been common knowledge for some years that this gain by steaming was an assured one if gas of a calorific value of 400 B.Th.u. to 450 B.Th.u. could be established as a saleable commodity. It was not equally certain what the effect of steaming would be on the other products, tar, coke and ammonia.

We can now say with confidence that there is not only a very substantial gain in therms in the form of gas, but also in the yields of tar and ammonia. I will only quote the results of one set of tests, which were carried out on a South Yorkshire coal of good quality.

At a working temperature of 1200 deg. C., and with 21 per cent. of steam, the gains per ton of coal were:

22 therms in the form of gas;
34 lbs. of tar; and
6 lbs. of ammonium sulphate.

While without steam only 23 per cent. of the potentia heat of the coal was obtained in the form of gas, with steam 33 per cent. was obtained. The extra heat which had to be supplied to the retorts in order to produce these results was 10 therms per ton of coal carbonised. It is estimated that the additional value of the products

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See ENGINEERING, July 12 and 19, 1918; July 25 and August 1, 1919; December 10 and 17, 1920.

obtained by steaming amount to at least 10*s.* per ton of coal carbonised.

The general adoption of steaming in vertical retorts will almost certainly be followed by a great extension of the use of this form of retort, and a very substantial saving will result, both as regards the gas undertakings and the consumers at large.

Conclusions.

From this brief review it appears that coal is likely to remain for a long time the world's chief source of fuel. Its more efficient use may be secured :

(1) By more careful sorting and preparation at the mine.

(2) By the improvement of boiler firing on well-known lines.

(3) By the sorting out of its combustible constituents into fuels of higher availability or convenience by preliminary carbonisation carried out either at high or low temperatures. This has an important bearing on the development of home sources of fuel oil and motor spirit and on the production of smokeless solid fuel for domestic purposes.

The development of oil shales as a source of liquid fuels is still only in its initial stages, but it has evidently a great future before it.

The problems of the utilisation of peat, which cover a wide range, both technically and economically, are mainly of local importance, and are not likely to affect the fuel supplies of the world to any great extent.

The production of alcohol on a really large scale as a motor fuel of high availability bristles with economic and technical difficulties, and it is still too soon to pronounce an opinion on the possibilities of the future.

Most, if not all, of these problems on their technical sides are probably capable of solution by the skill and application of the industrial pioneers of the world ; but the most difficult of the fuel problems of the future are those into which the human element enters so largely. At home the relations of the wage earning classes with the actual leaders who initiate and direct our industrial policy, and abroad, our relations with other nations who are equally interested with ourselves in the natural resources of the world, are profoundly affected by the spirit of the time. This spirit, as it is manifesting itself to-day, is fatal to the progress of reconstruction and development on any extensive scale and we, whose chief interest in life lies in the control and use of the powers and resources of nature for the service of man, can only continue to do the work next our hand, while we cherish the hope that the better side of human nature, which we know is only temporarily overshadowed, will gradually reassert itself.

INSTITUTION OF CIVIL ENGINEERS.
ENGINEERING CONFERENCE, 1921.*

SECTION I.—RAILWAYS, ROADS, BRIDGES AND TUNNELS.

The Structural Outlines of our Home Railways.

By Alexander Ross, M.Inst.C.E.

On September 15, 1830, the Liverpool and Manchester Railway was opened for public traffic, passengers, goods and minerals. This line may well be described as the pioneer railway of the world, and notwithstanding the many ill-advised obstacles that were placed in the way, the obvious advantages to be gained by rapid and effective means of communication were so convincing that the construction and extension of railways spread with amazing rapidity, not only in Great Britain and Ireland, but almost simultaneously in the United States of America, in Canada, and on the Continent of Europe ; and in the short period of the history of the world of 91 years railways have extended to South America, India, China, Japan, Burma, Siam and the Federated Malay States, and to Africa and Australasia. Railways are still being extended, and taken in conjunction with the progress made within the same period by navigation, electric cables, telegraphs and telephones, the utmost parts of the world have been bound together and rendered accessible.

From the commencement, our gauge between the running rails was fixed at 4 ft. 8½ in. This was not on the basis of any scientific reasoning, but simply on empirical grounds : still, it has proved itself wonderfully successful and was adopted by the Continent of Europe —Russia and Ireland excepted—the latter adopting the gauge of 5 ft. 3 in. Undoubtedly another 3½ in. added to the width of our gauge would have been a great improvement. This cannot now be entertained, and it only remains for us to make the utmost of our standard gauge as fixed. In the extension of railways to the wider fields of India, the Dominions and the Colonies, various gauges have been adopted, some greater than our standard, and in many cases less, the opening up of each country being kept in view.

The Liverpool and Manchester Railway was complete in its component parts, but it is scarcely necessary to add that as the railways developed the parts were greatly improved. The original width of the space between the running up and down roads, now known as the 6-ft. space, was only 4 ft. 8½ in., being the same as that of the gauge between the running lines, and had to be widened out afterwards.

The railways of this country are the creation of private enterprise in keen competition, and under these conditions steadily developed until 1914, when further progress was arrested by the breaking out of a disastrous war : they stood in the front rank, and were second to none as regards speed and comfort. Notwithstanding, it becomes inevitable that many changes must be effected for successful future working. Until quite recent years the railways were entirely operated by steam ; the aim is that for the future they shall be wholly operated by electricity. This of itself will dispose of many objections to steam railways ; still the process of conversion must be gradual, extending over many years, and operating at first in and around large towns, the areas gradually expanding until they meet.

The great blot on our railway system is the limit of capacity placed on our loading gauge, mainly the result of unorganised independent action and the absence of co-ordination among the companies. No other country followed our lead in this respect. It is suggested that our railway lines should be classified, No. 1 class embracing the main trunk lines ; and as regards the construction or reconstruction of this class the writer lays down the following propositions for discussion at this Conference. The 6-ft. space should be widened to 7 ft. at the least. In the case of more than two lines of rails, the space between the original pair of rails and additional lines shall not be less than 11 ft. 6 in. No overhead structure shall have less clear headway than 15 ft. 6 in. above the top surface of the rails. No structure higher than 2 ft. 6 in. above rail level should be nearer to the edge of the nearest rail than 5 ft. Incidentally this involves the question of raised platforms, which although adding greatly to the cost of our stations, we so much prize, and miss so much when travelling outside the country. Nevertheless, if continental rolling-stock is to be run on our lines, this subject must receive consideration.

In the case of four lines of way, what are the relative advantages and disadvantages of the lines being disposed in pairs up and down with the dividing wider space between, or the two main lines occupying the centre with an additional line on either side ?

Clearly such alterations as are indicated by this communication could only be effected gradually, the operations extending over many years, but if they are ever to be fully attained a commencement has to be made, and it is essential that railway authorities should in agreement make a united effort before standardised clearances can be adopted as generally acceptable. If in the future all new lines projected and all reconstructions were to conform to the regulations arrived at, with steady adherence, the railways of this country would in time—although possibly a very long time—vastly increase their capacity, and every decade would mark progress. The standardisation of component parts has already been effected to a greater extent than is generally supposed, but there is still room for further action, and co-operation is essential if uniform standards are to be adopted. The suggestions contained in this communication are necessary if the full capacity of our running gauge is to be attained. Much might be said about the necessity of coupling up the different railway systems so as to secure complete interchangeability and continuous running, but for reasons of space these notes are necessarily incomplete ; notwithstanding, it is hoped they may prove to be sufficient to provoke a useful discussion.

Tunnel Maintenance.

By Oswald George Cooper Drury, M.Inst.C.E.

On the system maintained by the Brighton Company there are forty-one tunnels, of a total length of 13·2 miles, running through chalk, clay, and sand or sand-rock. Abnormal works of maintenance have been carried out in eleven of these tunnels, aggregating 4¼ miles in length, or one-third of the total length of tunnels on the system. Of this 4¼ miles specially dealt with, 2·88 miles were in chalk tunnels, being about 40 per cent. of their total length ; 1¼ miles in clay tunnels, being about 38 per cent. of their total length ; and four-fifths of a mile in sand or sand-rock tunnels, being about 49 per cent. of their total length. The abnormal maintenance has therefore been practically equal in all three kinds of material.

Two sand tunnels were treated :

1. *Betchworth Tunnel.*—A 4-ring double-track tunnel, 385 yards long, on the Portsmouth main line, built in 1867. A portion collapsed in 1887. It was rebuilt in nine months at a cost of 145*l.* per lineal yard for the inverted portion, and 30*l.* per lineal yard for the portion where a relieving arch only was built. Full particulars can be found in a paper presented to the Institution by Mr. George Lopes in Session 1888–89.

2. *Micklesham Tunnel.*—A 4-ring double-track tunnel, 530 yards long, on the same line, the London side of Dorking Tunnel. Built in 1866, it developed weakness in the inner ring, due to bricks eroding and mortar perishing. In 1903 the inner ring was cut out (completely in the arch, and partially in the walls), and replaced by a brindle ring in cement. Work was carried out day and night, single line being worked at night. It took about three years to complete, cost about 12*l.* per lineal yard, and was done by contract.

Three clay tunnels have been dealt with :

1. *Balcombe Tunnel.*—A 5-ring double-track tunnel, very wet, 1,133 yards long, on the Brighton main line. Built in 1837 it developed weakness in the inner ring, parts of which failed due to the bricks eroding and mortar perishing and washing out. The side wall inner ring was cut out and replaced, and an additional ring turned in the arch in brindles in cement. The work was carried on day and night during traffic, single line being worked at night. It took about three years to complete, was done by labour contract, and cost about 11*l.* per lineal yard.

2. *Crystal Palace Tunnel.*—A 7-ring double-track tunnel, 745 yards long, under the South-Eastern and Chatham high-level Crystal Palace Station. Developed weakness in 1917 for a length of about 40 yards, the invert bursting up and the side wall closing in. The tunnel which is in the electrified area (overhead system) was shored, a dead length inserted in the overhead wires, single line working installed, and the bad portion cut out in 5-ft. lengths and rebuilt. The work was carried out day and night, departmentally, under Mr. J. Petrie, the district engineer, the electric current being used for lighting. The work took about nine months and cost about 230*l.* per lineal yard of tunnel dealt with.

3. *Rotherfield or Crowborough Tunnel.*—A 5-ring double-track very wet tunnel, 1,020 yards long, on the Lewes-Tunbridge Wells line. Built in 1864. A length of about 14 yards collapsed in 1903, distinct signs of crushing being found. Part of the walls were of the original sandstone. Where the fall occurred a cone 30 ft. high above the extrados was left, which was packed by faggots 4 ft. long, 18 in. diameter. A relieving arch was turned beneath the existing arch, part of the side walls was cut out and rebuilt, and part of the tunnel was inverted, a toe wall to the footings being built in other parts. The work was carried on day and night, single line being worked at night, and took two years to complete, costing about 20*l.* per lineal yard.

Three chalk tunnels may be mentioned :

1. *Clayton Tunnel.*—A 6-ring double-track tunnel on the Brighton main line, 2,266 yards long, built in 1837. Weakness developed in the inner ring, as much as three super yards falling from the arch at a time. This was found to be due to the perishing of the mortar, and it was decided to reline the whole arch with one additional inner ring of blue brindles in cement, and to carry this ring on continuous brick corbels of special bricks. Parts of the wall were also relined. The work extended over about eight years, and was carried out departmentally single line being worked at night for part of the time, the work later being done between trains day and night. After the work had been started with pit sand and cement, a slime was found on the joints, the removal of which disclosed a hard skin of mortar beneath. This skin in turn became soft and formed a new slime. It was found the same result could be obtained by putting similar mortar in sulphur fumes, and, in consequence, Thames sand washed on the works was substituted, with better results. The cost of the work was about 13*l.* per lineal yard.

2. *Cliftonville Tunnel.*—A 3-ring double-track tunnel on the Hove branch, 536 yards long, built in 1875. An area of about 16 ft. in diameter collapsed in 1917, due, no doubt, to a fall of chalk. It was found on examination that no packing had been done, there being spaces behind the walls of from a few inches to 2–3 ft., and outside the arch from a few inches up to 47 ft. long by 8 ft. to 17 ft. high. Access holes were cut in the arch above springing, and the spaces behind the walls and the smaller spaces over the arch were filled with concrete. In the larger spaces over the arch brick honeycombing was built. The work was done departmentally by the district engineer, Mr. F. B. Brown, and took nearly three years, the cost being about 17*l.* per lineal yard.

3. The last case of chalk tunnels is Oxted, a double-track tunnel 2,260 yards long on the Croydon and Oxted line. This tunnel has had attention at various times. It was started in 1865, and then stopped owing to financial troubles, and restarted and completed in 1883. Part of the walls for 570 yards from the north end were originally left unlined, the arch being turned on skewbacks cut in the original chalk. Side walls were subsequently built in this portion of the tunnel, and an additional ring, carried on continuous corbels, was built in blue brindles in cement for this length. From this portion of the tunnel there is a middle length of four rings left as built, and beyond this to the south end a further length of 6-ring work, inverted, the chalk being very loose and mixed with clay at this end.

A fall occurred in the tunnel for a length of about 40 ft. in the middle section in 1917, and a further fall at a shaft in 1919, and the late Sir James Ball determined to strengthen the middle band of 1,130 yards of 4-ring work not previously dealt with, and selected the Ingersoll cement gun as a suitable means. A contract was drawn up providing for the cutting of access holes for inspection and packing of spaces and for grouting under pressure and for pressure grouting through holes to be drilled in the brickwork, also a portion of relining was allowed for.

The contract was let to Messrs. Logan and Hemingway, but on opening up the tunnel parts of the brickwork were found to be defective, due to soft and underburnt bricks and shortage of mortar. In parts also the arch was distorted, and virtually no packing had been done. Spaces were found outside the walls as in the case of Cliftonville, averaging about 7 in. throughout and above the arch ranging from 3 in. to 14 ft. high. In view of its state Sir James decided to cut out and rebuild 5-ft. bands at intervals, and a certain amount was done this way, but this method has since been abandoned. Where the arch is found distorted it is being rebuilt, and in the remainder of the middle length grout only is being used. The work is not far enough advanced to give details, additional plant just having been installed, but the rate of work has varied from 7 lineal yards per week to over 30 lineal yards per week with half plant working, and the cost from 250*l.* per lineal yard for the work in the bands, to 60*l.* per lineal yard for the grouted portion. The amount of grout blown in averages about 8 cub. yards per yard run, a good deal of grout finding its way through the joints and holes cut in the brickwork, showing that a very large amount gets in the open joints.

The gun used is an Ingersoll No. N. 1, and the amount blown in averages 1 cub. yard per gun per hour. The pressure at compressor is 80 lb., falling to a minimum of 40 lb. per square inch at the gun, and about 40 h.p. is required to efficiently work the gun. The grout used is 5 of sea sand and 1 of cement. In addition to the grouting it is proposed to cover the face ring of the tunnel with the same mixture, blown on. Sufficient face

* Papers read on Wednesday, June 29, 1921.

work has already been done to prove its success, the old face bricks, which are badly coated with soot, being first cleaned with a jet of small sharp grit.

The next few months will show the value of the method of grouting, as the part of the work in which bands were rebuilt is now practically cleared up, and a free run for the cement gun is obtainable, but I think the method is a practical success from the point of view of stability and speed, although its commercial value has yet to be thoroughly tested. The costs given apply to the cost of carrying out the work on the tunnels only, and are average figures. Generally, the experience of tunnel maintenance on the Brighton line has shown that the troubles experienced are mainly due to the use of unsuitable material, and to the lack of proper supervision and care in carrying out the work during construction.

SECTIONS II AND V.—HARBOURS, DOCKS, RIVERS AND CANALS AND SHIPBUILDING.

To what Dimensions should Docks be Constructed to Provide for Future Requirements.

By CYRIL REGINALD SUTTON KIRKPATRICK, M.Inst.C.E.

At the Engineering Conference in 1907 the Right Hon. Lord Pirrie contributed a valuable Note upon "Harbour and Dock Requirements as affected by the Development of Shipping." The keynote of the paper and of the interesting discussion which took place was to urge upon port authorities the necessity of providing a considerable margin in dimensions over those actually required at the time of construction so as to allow for future development in shipbuilding.

In 1912 the late Dr. Elmer Corthell submitted a report to the Twelfth International Congress of Navigation at Philadelphia, entitled "Dimensions to be given to Maritime Canals taking in account the probable dimensions of Ocean Ships of the Future." His views were then expressed in the following words: "As to the locks, in the case of lock canals or entrance locks to the principal ports or canals with tidal locks, they should be large enough to receive in their chambers the maximum size vessels, both commercial and naval, of the world, that is vessels 1,100 ft. (335 m.) long, 110 ft. (33·5 m.) wide with 40 ft. (12·2 m.) draught, or a usable length of lock of 1,150 ft. (350·5 m.), 130 ft. width (39·6 m.), and 45 ft. (13·7 m.) depth of water. These dimensions will also allow the entrance of a warship 120 ft. (36·6 m.) wide, the draught and length of which will, no doubt, always be less than that of the largest commercial ships."

In a memorandum prepared by the Right Hon. Lord Pirrie in 1913 for the Dominions Royal Commission he advocated that the minimum depth of water required in a first-class harbour was then 40 ft., but in view of the time which it takes to provide harbour facilities he recommended that a depth of 45 ft. should be aimed at.

Sir John Biles submitted a memorandum to the same Commission in 1915, and expressed the opinion "that to obtain the most economic transport a vessel of a length of at least 750 ft., having a draught of 43·2 ft., should be provided for"—and that circumstances "would make the 1,000 ft. ship a more economical carrier than the 750 ft. ship. From this would follow the necessity of a draught corresponding to 1,000 ft. length which is 57·6 ft. Therefore it seems that an improvement in construction involving a reduction in weight of structure must be accompanied by an increase of depth of harbour before it can be made profitable. It is not unreasonable to predict therefore that within 20 or 30 years a depth of harbour of 60 ft. could be profitably employed."

After hearing much evidence the Dominions Royal Commission, in their Final Report in 1918, came to the following conclusions:—"Summing up the position as a whole we are of opinion that certain ports on the various trade routes with which we have dealt, can, and should, be deepened and enlarged so that accommodation may be provided throughout these routes for vessels of the following draughts:—

"(*a*) 33 ft. on the route from the United Kingdom via the Suez Canal to the East and Australia.

"(*b*) 34 ft. on the route from Western Canada to New Zealand and Australia.

"(*c*) 38 ft. on the routes from the United Kingdom:

"(1) To Eastern Canada.

"(2) To Australia and New Zealand via the Union of South Africa.

"(3) To New Zealand and Australia via Halifax, Jamaica, and the Panama Canal.

"We are of opinion also that action should be taken, where necessary, to secure dry-dock accommodation in the self-governing Dominions for vessels of these draughts and of the corresponding economic lengths."

To-day there are no giant merchant ships under construction, and there are only five such vessels afloat over 800 ft. in length. It is desired to obtain the views of engineers and shipbuilders whether vessels of over 800 ft. in length will be built in the future or whether the limit may be taken as 800 ft.

The author submits that the present check in giant ship construction is a temporary one and due to the following causes:—(1) Absence of adequate port facilities for accommodation and repairing; (2) high cost of construction and repair; (3) dear money; (4) difficulty in insuring such high values of craft and cargo in one bottom.

He also submits that if facilities are provided by port authorities giant ships will be again constructed as soon as a new standard of values has been reached, and that it is, therefore, necessary that the dimensions for an entrance lock for any dock intended to take the largest merchant vessels should still be constructed not less than those laid down by the late Dr. Corthell, namely, 1,150 ft. long by 130 ft. wide, with a depth of 45 ft. The provision of accommodation for such large vessels includes not only entrance lock, docks, and dry docks, but also deeper approach channels, larger transit sheds, cranes with greater outreach, and more adequate railway sidings and approach roads. It is admitted that the additional capital involved in the provision of accommodation for vessels of 1,100 ft. instead of 800 ft. is large, but the construction of port improvements is no light undertaking and is necessarily extended over a period of years. History has shown that port authorities have had repeatedly to reconstruct in order to accommodate the growing size of vessels. In some instances, indeed, it has happened that before the improvements have been completed they have been found to be of insufficient size to meet the purpose for which they were intended.

Ship and Harbour Design and Equipment as Affecting the Rapid Loading and Discharging of Cargo Vessels.

By ARTHUR ROBERT THOMAS WOODS.

The subject which I have been asked to introduce for discussion is not only of great importance, but is so comprehensive that in the short time at my disposal I can only briefly allude to some of its more salient features.

During 1920 the weight of imports landed at the ports of the United Kingdom was 45,500,000 tons, of which quantity one-third consisted of foodstuffs, and one-half of raw materials. The exports of United Kingdom produce during the same period amounted to 39,500,000 tons, of which coal accounted for 28,500,000 tons. During the same period 13,800,000 tons of bunker coal were shipped at United Kingdom ports for the use of vessels engaged in the foreign trade. Thus, taking the foreign trade alone, the traffic handled at the ports of the United Kingdom during 1920 was:—

	Tons.
Imports	45,500,000
Exports	39,500,000
Bunkers	13,800,000
Total	98,800,000

There were also 1,600,000 tons of re-exports, so that ships and docks had to provide transport and handling facilities for over 100,000,000 tons of traffic. Under present conditions the failure of the machinery provided on shore for the handling and distribution of goods to give quick dispatch, has led to fewer voyages being made and thus reduced the potential carrying capacity of the ships engaged in the foreign trade by something like 20 per cent.

Under these circumstances the problem of how to secure a freer flow of goods through the ports is one of national importance. In any attempt at finding a solution of the problem and its many consequential difficulties, it should be clearly borne in mind that a principal causative factor in port congestion is the shorter time now worked by dockers, railway men and other transport workers; and, secondly, that the shift system, under which continuous loading and discharging could take place, is not popular, and is, perhaps, hardly feasible except in cases of great emergency. There is therefore no hope of salvation from that quarter any more than there is in the suggestion for a quantitative increase in the labour element. We are thus compelled to explore the avenue of possible improvements in the cargo-handling equipment of ships and docks.

It may be stated as a general proposition that the British shipowner recognises the importance of specialising. As a rule, his vessels are structurally adapted and equipped for the particular trade in which it is intended to run them and for the cargoes they will carry. The number and size of hatchways, and the number and type of winches cranes and derricks, are all carefully worked out, with the result that in the case of modern "tramps," which perform the greater part of our cargo carrying, these facilities for manipulating cargo are in many instances superior to those of the foreign ports they visit. Tramp owners are thoroughly appreciative of the fact that their vessels—which are built to go anywhere and carry anything—must be largely dependent upon their own equipment.

But, however efficient a ship's gear may be, it is essential that it should be supplemented by good organisation on shore and also by the provision of mechanical appliances in accordance with the best practice. It is only by the provision of such devices that the diminished output of labour can be compensated for. Although dock and harbour authorities are generally blamed for a lack of enthusiasm in providing additional mechanical plant, it must, in fairness, be admitted that they were faced with a difficult situation when the hours of labour were shortened, practically without warning, and certainly without any preconsideration as to how the difficulties so suddenly created, were to be overcome. If the berthage accommodation for shipping could have been immediately extended, more men, of course, could have been employed; but even if this had been physically possible the other departments of transport would have had to come into line to obviate the congestion due to the shorter hours which they worked. Without such co-ordination of effort, the ships might have been cleared at the expense of converting the dock estates into vast cargo dumps suffering serious deterioration and providing increased opportunity for pilferage.

It is an obvious but unpleasant truth that the majority of British dock systems suffer from want of foresight, not anticipating the rapid developments of ship construction and the need for increased accommodation. Their origins were in the remote days of the small sailing vessel, since which time it has been a perpetual struggle to enlarge and equip them for the needs of modern ships and present-day commerce. A late chairman of the Mersey Docks and Harbour Board once very aptly remarked that the problem which continually faced them was that of trying to make a silk purse out of a sow's ear. The Port of London Authority is confronted with the same difficulty, and their efforts, and the efforts of their predecessors to find a solution, have resulted in the provision of detached dock groups extending from the Tower Bridge to Tilbury, practically all of which labour under the serious disability of inadequate rail connection with London and the main arterial systems of the country. The new Albert Dock of 65 acres and relatively little quay space for its great size, may afford some measure of relief to shipping using the Port of London; but the cheaper and more efficient plan of providing facilities for the trade and commerce of the metropolis is by the dockising of the Thames, a scheme which presents no insuperable engineering difficulties, and which would facilitate the manipulation both of ships and cargoes.

What we are more concerned with, however, at present is the provision of additional mechanical equipment to enable shipping to increase its earning power by a reduction of the time spent in loading and discharging. The winch and the cargo crane have been good servants in the past, but there is a tendency on the part of dock authorities to rely too much upon devices of this type. The conveyor system has demonstrated its applicability to grain cargoes, chests of tea, and generally to what may be termed "parcel and bag" cargo. The extension of facilities of this type would prove of undoubted value in increasing the rate of discharge. Double-storey sheds equipped with roof cranes which have done such good work at Liverpool should be more generally adopted. Simultaneously with discharge into the sheds cargo can be swung from ship to roadway and immediately loaded into rail trucks or road vehicles. In ports where waterborne cargo forms a prominent feature, the barge question is one of grave importance. It is only by the provision of increased mechanical contrivances for dealing with cargo that the free flow of traffic through the ports necessary to enable ships to work at full capacity can be secured.

In this brief introduction of a subject of vital importance to the national prosperity I have merely indicated the nature of the problem which confronts us, and suggested the direction in which the solution may lie. That solution must not be delayed, for upon it depends in great measure the well-being, and, indeed, the maintenance of our overseas trade.

The Development of Cranage Facilities for Discharging Vessels of the Largest Size.

By HENRY JAMES DEANE, B.E., M.Inst.C.E.

The intention of these notes is to deal with present-day conditions rather than circumstances which dictated the developments in the past. There is little doubt that before the general introduction of steam-driven vessels the discharge of the old sailing ships was carried out almost exclusively by manual labour. Time was not so important an element then as it is now, and, moreover, the dimensions of those ships did not enable them to carry so much merchandise per lineal foot of ship as the modern cargo vessel, and the small holds could easily be discharged within a comparatively short time. The growth in the size of such vessels can, as regards the first half of the last century, be fairly well visualised by reference to the dimensions to which the old lock entrances were originally constructed; and the developments in the latter half are shown on the diagrams attached to Mr. J. Foster King's report to the Twelfth International Congress of Navigation at Philadelphia in 1912, entitled "Probable dimensions of the sea-going vessels of the future," from which the following approximate average maximum dimensions have been taken:—

Cargo Vessels.

—	1854.	1880.	1900.	1920 (Predicted).
Length ..	225	335	400	475
Breadth ..	26	40	55	66
Draught ..	7	22½	26	29½

Passenger Vessels.

—	1854.	1880.	1900.	1920 (Predicted).
Length ..	340	450	600	650
Breadth ..	42	50	65	76
Draught ..	23	27	32	34

The carrying capacities of typical cargo vessels have an important bearing on the present subject, and the following data have been deduced from a paper by Mr. John Anderson read before the Institution of Naval Architects (*vide* ENGINEERING, March 22, 1918). Attention is directed to the last column of "Cargo densities."

Length.	Breadth.	Depth.	Draught.	Cargo-Carrying Capacity.	"Cargo Density" per Lineal Foot.
ft.	ft.	ft.	ft. in.	tons	tons
250	37	18½	16 7½	1,387	5·55
330	45	24½	20 9½	3,885	11·77
410	53	30½	24 11½	7,357	17·94
490	61	36½	27 11	11,986	24·46
570	69	42½	31 7	18,358	32·21
650	—	—	—	23,000	40·00

The cargo-carrying capacities of some of the largest passenger vessels is set out below, and attention is also directed to the last column of "Cargo densities."

Name of Vessel.	Length.	Cargo-Carrying Capacity.	"Cargo Density" per Lineal Foot.
	ft. in.	tons	tons
Andania	520 0	9,634	18·52
Transylvania.. ..	548 0	8,826	16·10
Naldera	580 9	5,066	8·72
Caronia	650 0	9,907	15·24
Mauretania	760 0	3,840	5·05
Aquitania	865 0	5,115	5·91

The most important landmark in the history of cranage facilities was in the year 1846 when Lord Armstrong first applied hydraulic power to quay cranes, and this was rapidly followed by the equipment of docks and harbours with complete hydraulic installations, including pumps, mains and cranes. Since when, up to the present day, progress has been parallel with the growth in the size of ships and has been amplified by the introduction of electrical power as applied to cranes.

A comparison of the various speeds and dimensions of the early hydraulic with a typical modern electric quay crane is as follows :—

——	1854 Early Hydraulic.	1921 Modern Electric.
Lifting capacity..	1 ton	1½ tons
Alternative capacity	3 tons	3 tons
Maximum radius of jib ..	24 ft.	65 ft.
Outreach beyond quay.. ..	21 ft.	54 ft.
Height of jib sheave above quay at maximum radius	26 ft.	67 ft.
Total drift	36 ft. 10 in.	105 ft.
Total weight of crane	23 tons	60 tons
Weight of revolving parts, excluding load	—	34 tons
Speed of hoisting	4 ft. per sec.	2·5 ft. per sec.
Speed of sluing	30 deg. per sec.	6 deg. per sec.
Speed of luffing	—	1¼ ft. per sec.

It is obvious that cranage facilities necessarily have to be designed to suit the shipping which is likely to frequent the port and, in preparing specifications, a large number of considerations must therefore be taken into account which, amongst others, give rise to the following questions :—

1. Whether cargo vessels, generally speaking, are likely to increase much beyond the present maximum dimensions and, if so, is it probable that such vessels will be equipped with their own cargo handling appliances (as is already done in numerous cases) ?

2. Whether the largest modern liners of the trans-Atlantic passenger type can be considered seriously (for the purpose of port cranage facilities) as cargo-carrying vessels and, if so, should such facilities be provided on the quayside, or should the owners of such vessels be expected or required to furnish the necessary equipment on the vessels ?

3. If the future requirements of shipping remain generally as they are to-day (namely, that the port authority should provide the cranage equipment) to what leading dimensions should such equipment be designed ? and

3A. Is the present general type of luffing and sluing jib crane, with or without horizontal luffing contrivances, the most economical, efficient and satisfactory type to follow ? or

3B. Should some more simple design be aimed at in which the weight of the structure and more particularly its moving parts are brought down materially, the number of motions (namely, three or more) reduced, and the handling of cargo materially speeded up ?

In dealing with these and many other points which arise it is of importance to keep in view the very debatable question as to whether cranage equipment provided by the port authority should be reckoned as a dividend-earning facility or whether it should be looked upon as a necessary expenditure which is only partly met by the revenues directly derived therefrom. No reference has been made to continuous conveyors or handling appliances for special commodities, as this is not a matter within the range of the subject under discussion.

SECTION V.—SHIPBUILDING.

THE NECESSITY FOR, AND THE POSSIBILITY OF DEVELOPMENT OF, THE COASTING TRADE.

By WILLIAM LIVINGSTONE ROXBURGH.

No truer statement was uttered during the war than that of the Prime Minister when, at a critical period of our fortunes, he said : "The mercantile marine was the jugular vein of the nation," and cried aloud for ships—and more ships—to replace the losses caused by enemy submarines and mines. The statement was not confined to vessels engaged in the overseas trade, but included those engaged in the coastwise and short sea trades. However, I must confine myself to the su ject of this Note—namely, the necessity for and development of the coasting trade, and endeavour to show the important part it holds in the commerce of the country. The problem of our transport is not a sectional, but a national, one. It is a problem of the greatest importance to the whole nation, and should, therefore, be settled by statesmen. It is one of the most important problems of economic statesmanship. The traffic lines of a nation are like the arteries of the human body ; they have a similar function. The free and vigorous circulation of the blood is essential to the health of the individual. Even so, the free and unimpeded flow of traffic is necessary to the health of the body economic and of the body political. An impeded flow of traffic within a nation leads to the most disastrous results, as witness the recent Russian revolution, which was chiefly caused by the breakdown of internal communications.

The coastwise trade existed before railways were known, and the vessels engaged therein, be they schooners or the latest palatial liner, may safely claim to be the aristocrats (poor though they be) of the transport trade of the country. The railways were orginally planned for small traffic ; no one could foresee their gigantic development. As trade increased so did the network of rails, with the result that in their early history our railways had a hard struggle against insolvency owing to competition between rival lines ; many local lines gave up the struggle, and were absorbed by what are known as the great trunk lines, several of the leading railways being made up of defunct local lines, grouped together. In order to defeat their competitors by water, they purchased important canals, and strangled their traffic in order to acquire it themselves. Besides, they purchased harbours and docks, with a view of diverting trade from the coastal shipping to their own lines. Being determined to secure all the traffic obtainable, they quoted exceptionally low rates where water competition existed. The struggle between the railways and coasters has been lifelong, but the water route managed to hold its own until the Government controlled the railways, and made up their losses out of the taxpayers' pocket. In a recent report of the Rates Advisory Committee, appointed by the Ministry of Transport to investigate and report upon increasing the railway rates, and putting the railways on an economic basis, the report, after reviewing the extraordinary manner in which railway rates had been cut below those ruling on inland routes in order to meet water competition, stated that "it is of first-rate importance that the exceptional rates, which were brought into operation to meet competition by water, should not be continued or form the basis of new rates, if carriage by coasting vessels and by canals is to be preserved, which, in our opinion, is essential. The shipping industry in the coasting trade is a very important one, and the preservation of alternative routes from port to port is of great moment to the trading community."

Great Britain is more favourably situated for extending the coastal shipping trade than most countries ; the great majority of the population, and the most important industrial centres, are on or very near to the sea, and all that it demands is that it should be given the chance of competing for traffic on sound economic lines. The development of the sea route has very important advantages. Carriage by water is cheaper than by land, and the existence of artificially cheapened railway rates does not alter that fact. From a national point of view it is wasteful to transport goods by land which could more cheaply be carried by sea. It is necessary the nation should have an alternative system of transport, if through some cause or other the railways should be brought to a standstill : furthermore, the coasting trade is an important training ground for British seamen. The two greatest British resources are manufacturing and trade. The British Empire being a sea empire, the oversea trade is of vital importance to these Isles. A highly developed British coasting trade would be an undoubted benefit to both the merchant marine and our foreign trade. Cheapening of transport rates is of the greatest importance to our industries, and to the workers engaged in them. Only by cheapening our goods can we hope to retain our position in the world's markets. The coastal shipping acts as feeders to the ocean-going vessels, by receiving and delivering cargo alongside, thereby saving heavy terminal charges as well as time to the ocean ships, which is a very considerable item. What the inland waterways are to Germany, the sea is to the United Kingdom, but many are unaware that there are about 70 smaller ports all around the coast which could be developed into most valuable agencies for handling our traffic—thuogh many of the minor ports require to be improved and supplied with more modern appliances. For many years the development of our coastwise trade was kept back by the railways ; while our oversea trade expanded rapidly our coastwise trade stagnated. If we compare the period 1860–64 with the period 1910–14, we find that the entrances of shipping increased five and a half times, while that of the coasting trade merely doubled. During the forty years preceding the war, whilst the foreign trade increased enormously, the coasting trade, which is employed in assisting the foreign trade by collecting and distributing goods around the coast, remained practically stationary. The following table shows the decline which has taken place within recent years :—

Coasting Tonnage Entered with Cargoes in Great Britain.

	Tons Net (Average).
1910–14	21,870,000
1915	14,980,000
1916	11,070,000
1917	8,920,000
1918	7,370,000
1919	10,170,000

During the war years the tonnage employed in the coasting trade shrunk to one-third, not so much owing to the loss of ships as owing to the artificial cheapness of the rates charged by the railways ; and the continuance of the uneconomic railway rates has impeded its recovery.

In conclusion, I should like to state that in my opinion a highly-developed coastal shipping trade able to make use of the 70 smaller ports equipped with all modern appliances around the coast, would vastly increase the efficiency and the carrying power of our merchant marine. By wisely expanding a comparatively moderate sum in bringing these ports up to date and also deepening channels and providing locks at the larger ports, whereby vessels could enter and leave at any state of the tide, much loss of time waiting for high water would be avoided and the coaster put on more equal terms with the railways, which have none of these delays to contend with, thereby securing fair treatment to the coasters and enabling both ports and coasters to flourish, very greatly to the advantage of the nation.

CATALOGUES.

X-Ray Accessories.—Catalogues of a series of X-ray plates, films and accessories have been issued by Messrs. Watson and Sons (Electro Medical), Limited, Parker-street, Kingsway, London, W.C. 2.

Twist Drills.—A small pamphlet, for circulation in the workshop, explaining practical points in connection with the grinding and use of twist drills, has been issued, by the Sheffield Twist Drill and Steel Company, Limited, Summerfield-street, Sheffield.

Lubrication.—Messrs. C. C. Wakefield and Co., Limited, Cheapside, London, E.C. 2, send a little book of useful notes on the operation of steam turbines. The firm supply special lubricating oils and high-speed oil filters for turbine work.

Sheathed Cables.—A new supplement to their catalogue of wires and cables has been issued by Messrs. Siemens Brothers and Co., Limited, Caxton House, Westminster, London, S.W. 1, containing lists of cab-tyre sheathed cables and flexibles, with full particulars and prices.

Tubes.—A clearly-written pamphlet, in English, explaining the advantages of their S-tubes and spiral superheater tubes, as compared with smooth-walled tubes, has reached us from Messrs. K. E. Nordling and R. Bengtzon, Amal, Sweden. A considerable fuel saving is claimed.

Boiler Tube Cleaners.—The tube cleaner with revolving cutters for removing soot and scale from the inside of tubes, made by the Roto Company, Hartford, Conn., U.S.A., is the subject of a special catalogue received from the agent for this country, Mr. O. N. Beck, 11, Queen Victoria-street, London, E.C. 4.

Contactor Switchgear.—High tension contactors for controlling a line circuit, either reversing or non-reversing, and automatic contactor starters for three-phase non-reversing squirrel cage motors are explained and illustrated in special leaf catalogues received from the Metropolitan-Vickers Electrical Company, Limited, 20, Brazennose-street, Manchester.

Electric Lamps.—Metal filament lamps of the vacuum gas-filled types, special lamps for motor cars and flash lamps, and a number of carbon filament lamps, are dealt with in a catalogue issued by the General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4. Illustrations and complete tables of particulars are given for each class and prices are stated in all cases.

Petrol Engine.—A four-cylinder petrol engine of 16 h.p. to 20 h.p., suitable for pleasure cars and light vehicles, has recently been put on the market by Messrs. Hick, Hargreaves and Co., Limited, Bolton, who send a catalogue describing the engine. All parts are made to interchangeable limits and spare parts can be supplied. The R.A.C. rating is 15·9 h.p. and the net weight 5 cwt.

Vertical Turret Lathe.—The Bullard vertical lathe is the subject of a very handsome 96 pp. quarto catalogue received from Messrs. Alfred Herbert, Limited, Coventry, who are the sole agents in this country for this tool. The design is convenient, especially for heavy chuck work. The turret slides vertically and revolves on a horizontal axis and there is also a cross slide, giving the same facilities for multiple tool work as are given by the horizontal turret lathe.

Cask-Making Machinery.—One of the most highly interesting and instructive of British engineering catalogues, extending to 140 quarto pages and dealing with a full range of machines for cask-making comes from Messrs. A. Ransome and Co., Limited, Newark-on-Trent. It gives particulars of machines for every operation from through cutting of the logs to the branding or printing the finished casks. The text explains the reasons for the methods adopted and the choice of materials as well as a description of the machines. The preface states that no complete technical treatise on cask-making has been published ; but this catalogue answers the purpose very well. There are good indices alphabetical and subject, and a full supply of relevant commercial information.

Electrical Apparatus.—Three catalogues to hand from Mr. George Ellison, Perry Bar, Birmingham, deal with a variety of electrical apparatus of his manufacture. The first is specially devoted to totally-enclosed, non-automatic, oil-cooled rotor starters for slip-ring induction motors, suitable for factories generally and also for gas works, quarries, iron mines and collieries. The complete and precise technical information in this catalogue will be appreciated by engineers in charge of plant. The second is concerned with cable fittings, pipe flanges, sealing and dividing boxes and armour clamps and glands, all specially designed for connecting ironclad switch gear to cables. The third deals solely with totally-enclosed brake solenoids, or power magnets for use on direct-current circuits up to 650 volts. They are fitted with adjustable dashpots to apply the brake gradually and release it freely. These catalogues are carefully prepared with all necessary technical and commercial information.